THE LIGHT CURVE OF NOVA PUPPIS

ALL of our readers are familiar with the common method of representing the changes in the light of a star by means of a graph, in which the time element is the horizontal co-ordinate and the magnitude is the vertical co-ordinate. The accompanying diagram will indicate at a glance how the recently discovered nova in Puppis has changed in brilliance during its first month.

More than 100 observations have been received at Harvard and these observations cover every night but two since discovery. Especially valuable contributions have been received from Pettit, of Mt. Wilson Observatory; Morgan, of Yerkes Observatory; McLaughlin, of the University of Michigan; and the observers at Harvard; besides the following A.A.V.S.O. observers: Bouton, Fernald, Halbach, Hartmann, Manlin, Monnig, Peltier, Rosebrugh, and Sanders. Many others have sent in sporadic observations.

What the brightness of the nova was prior to November 9th, we can not even guess. It could not have been very brilliant or it would certainly have been seen by someone some place on the face of the earth, particularly by an observer in the Southern Hemisphere where the nova was well situated for observation. We do know that it must have risen from at least the 17th magnitude before November 9th. The great and sudden increase in brightness could have taken place in a day or two, judging by the manner in which many other novae have behaved. We also know that when first detected by Dawson, Nova Puppis was of nearly the 1st magnitude and observations made by later discoverers on that same date indicate that the nova was a little brighter later in the night—apparently still on the increase. For a night or two it remained at a magnitude slightly above the 1st, and on the morning of the 12th, it apparently reached its greatest brilliance, halfway between magnitudes one and zero.

Immediately, the star began to decrease in brightness, somewhat rapidly at first, then more slowly. By November 17th, it had faded to the 3rd magnitude; on the 21st it had reached the 4th; and by the 26th, the nova was of the 5th magnitude, and somewhat difficult to observe with the naked eye. Now, a month after discovery, the star is practically of the 6th magnitude and changing very slowly.

Northern observers have noted that because of the star's low altitude, red color, and diminished brightness, observations were more difficult in early December.

Comparing the light curve of this nova with those of other bright novae, it can be said that Nova Puppis has faded away much more rapidly than has usually been the case for its predecessors, especially in the first week or two after its spectacular appearance. What it does in the immediate future is anyone's guess. The star should be carefully observed for as long a time as possible, especially by far southern observers, for if we are to study the spectral changes which are taking place, we must know all that is possible about the variations of its light.

LEON CAMPBELL
A.A.V.S.O. Recorder

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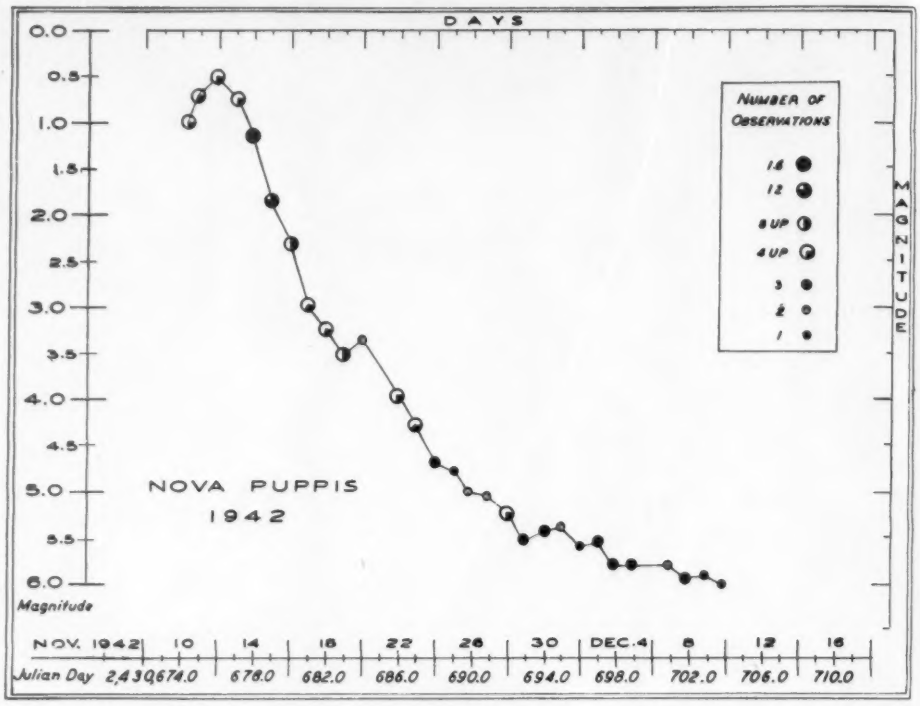

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BACK COVER: M81, N.G.C. 3031, an intermediate type spiral in Ursa Major, photographed with the 60-inch reflector at Mt. Wilson, exposure, 4^h 15^m. The galaxy, which has a very bright central portion, is about 16′ by 10′, with a photographic magnitude of 8.9. Its 1950 position is 9^h 51.5^m, 69° 18′.

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ISAAC NEWTON (1643-1727)

By I. Bernard Cohen

Harvard University

IF some one were to ask which two successive years were the greatest—from the point of view of anniversaries—in the history of science, he would be hard put to find a more significant pair than '42 and '43. They commemorate the death of Galileo, the birth of Newton, the death of Copernicus and the publication of his *De Revolutionibus*, and the publication of Vesalius' "Anatomy." These last two books were both published in the same year, 1543, and they mark, in an exact sense, the beginning of the modern scientific era. One dates the beginning of modern astronomy and cosmology, the other, of anatomy and physiology.

It is often said that Galileo died in the same year that Newton was born—1642. A contemporary philosopher even uses this "fact" as the basis of a paean of thanks for the continuity in scientific progress. But this statement is not exactly true. Galileo died on January 8, 1642. Was Newton born in 1642 or 1643?

Isaac Newton was born on Christmas Day, 1642, according to the parish records. England was then using the Julian calendar, and there was a 10-day difference between dates in England and in those countries where the Gregorian calendar had already been introduced. Thus Newton's birthday was denominated January 4, 1643, in those countries. The British Astronomical Association has therefore decided to celebrate Newton's birthday on January 4, 1943.

Newton was born in the little hamlet of Woolsthorpe, some seven miles south of Grantham, in Lincolnshire. We may mark the time in our minds by recalling that Harvard College had been founded some six years earlier; that Louis XIV, the "grand monarch," was then but five years old; and that Shakespeare had been dead for 22 years.

FOR the purposes of discussion, we may divide Newton's life conveniently into three periods. The first of these ends with his appointment, at the age of 27, to the Lucasian Professorship of Mathematics at the University of Cambridge in 1669. For the history of science, the most interesting—as well as the most significant—part of this period is the two years which Newton, after graduation from Cambridge, spent in seclusion at his birthplace in Woolsthorpe. Newton's most recent biographer, Dean More, remarks: "There are no other examples of achievement in the history of science to compare with that of Newton during these two golden years." From August, 1665, to March, 1667, young Newton made three great discoveries, each of which alone would have entitled him to a most distinguished position in the history of science.

The first of these was purely mathematical, namely, the method of *fluxions*, which we now know under the name of the differential calculus. This branch of mathematics today is the chief instrument by which those who investigate physical science solve the problems of nature. The second was the law of dispersion and composition of white light. The third was the law of universal gravitation.

Newton had been experimenting with the well-known effects of passing white light through a prism. But, whereas his contemporaries had merely observed the beautiful color of this "artificial rainbow," Newton proceeded to observe the details of the phenomenon and to analyze them. He discovered that white light is broken up by the prism into light of different colors and different degrees of refrangibility, and, in addition, that if he separated light of one color from the dispersed light and passed it through a second prism, there was no further decomposition. He also found that a second prism placed in a diametrically opposite position to the first or dispersing prism would recombine the many colors into white light once again.

Newton was quick to realize that herein lay the key to the nature of color and the explanation of the rainbow. He also saw that the disturbing chromatic aberration of refracting telescopes was a result of the different degrees of refrangibility of the component colors of light. He therefore designed the reflecting telescope in order to prevent chromatic aberration. Later, Dollond and Klingenstierna showed that chromatic aberration could be corrected by the judicious combination of different materials such as crown glass and flint glass.

From the point of view of astronomy, Newton's discovery is interesting in many ways. First, it laid the foundation for the science of spectroscopy which is today the chief tool of the physicist and astronomer in unraveling the problems of matter. Second, it marked, in its application, the birth of the reflecting telescope. And, third, it formed a kind of continuity between Galileo and Newton. Galileo was the first person to use the telescope as an astronomical (or scientific) instrument.

The third discovery made by Newton during this two-year period was the law of universal gravitation. The best statement of its importance is that of Laplace, the great French astronomer, who was notorious for his refusal to praise the work of others, whether contemporaries or predecessors. Laplace wrote that there is but one "Cosmos," hence one law governing it. "It was reserved for Newton to make known to us the general principle of celestial motions."

One of the anecdotes which everyone knows is that Newton arrived at the law of universal gravitation by observing the fall of an apple. The usual source of the story is the account given by Vol-

Newton's birthplace in Woolsthorpe. (Reproduced from Greenstreet, Reference 5.)

Model of the first reflecting telescope, made by Newton and presented by him to the Royal Society. (Reproduced from Brewster, Reference 3.)

taire in his "Elements of Newtonian Philosophy." The story has been discussed several times previously in *Sky and Telescope*, and with the conclusion that it is as untrue as it is absurd. But, however absurd it may be, it is nevertheless true. Recently an unpublished life of Newton came to light. It was written by the Rev. William Stukeley, physician and divine, and one of the best-known antiquaries of the 18th century. He is of especial interest to American readers since he was the first man in England to recognize the value of Franklin's hypothesis concerning the electrical nature of lightning, long before it was confirmed.

Stukeley was a friend of Newton's, a Fellow of the Royal Society, and, in his own phrase, "a countryman of Sir Isaac Newton's"; he lived a number of years in Grantham. A careful writer, Stukeley makes a cautious distinction between the three parts of his biography: "I. What I knew of him personally, whilst I resided in London, in the flourishing part of my life. II. What I gathered of his family and education at Grantham . . . . III. Of his character." Stukeley's account, which follows verbatim, corroborates the story told by Voltaire (who had got it from Newton's niece) in every detail. Here it is:

> After dinner, the weather being warm we went into the garden and drank thea [T], under the shade of some apple-trees, only he and myself. Amidst other discourse, he told me, he was just in the same situation, as when formerly, the notion of gravitation came into his mind. It was occasion'd by the fall of an apple, as he sat in a contemplative mood. Why should that apple always descend perpendicularly to the ground, thought he to himself. Why should it not go sideways or upwards, but constantly to the earths centre? Assuredly, the reason is, that the earth draws it. There must be a drawing power in matter: and the sum of the drawing power in the matter of the earth must be in the earths centre, not in any side of the earth. Therefore does this apple fall perpendicularly, or towards the centre. If matter thus draws matter, it must be in proportion of its quantity. Therefore the apple draws the earth, as well as the earth draws the apple. That there is a power, like that we here call gravity, which extends itself thro' the universe.
>
> And thus by degrees he began to apply this property of gravitation to the motion of the earth and of the heavenly bodys, to consider their distances; their magnitudes and their periodical revolutions; to find out, that this property conjointly with a progressive motion impressed on them at the beginning, perfectly solv'd their circular courses; kept the planets from falling upon one another, or dropping all together into one centre; and thus he unfolded the Universe. This was the birth of those amazing discoverys, whereby he built philosophy on a solid foundation, to the astonishment of all Europe.

When Stukeley's *Life*, which had lain untouched for almost 200 years, was published, the distinguished Belgian historian of science, Jean Pelseneer, pointed out that at last we had unimpeachable evidence that the apple story originated with Newton himself and not in the fanciful mind of Voltaire.

THE second period of Newton's life ends with his appointment as Warden of the Mint some 25 years after the Lucasian Professorship appointment, in 1669, had opened his public career. In this interval, he produced the great works which brought him scientific fame, and which consummated the three chief discoveries of the first period.

Newton's first published paper was devoted to an account of his investigation of the prismatic spectrum. Several writers, chief among them Hooke, objected to Newton's advocacy of the corpuscular theory of light. Newton replied to the objections and a long controversy ensued. He found this controversy so disagreeable that he declared: "I intend to be no more further solicitous about matters of philosophy [science]." And he blamed "my own imprudence with parting for so substantial a blessing as my quiet to run after a shadow."

So repugnant to him was this consequence of fame—the possibility of criticism—that he protested he would not allow his works to be published until after his death. "It may be said, without great exaggeration," writes Dean More, "that it was as difficult to force his mind to divulge his ideas as it had been for him to create them." De Morgan tells us that a discovery of Newton's was "of a two-fold character—he made it, and then others had to find out that he had made it."

But an even greater controversy was in store for Isaac Newton, the one with Leibniz over credit for the discovery of the differential calculus. The arguments were heated on the part of the two scientists and their respective supporters, although it is generally agreed today that both discoveries had been made independently. Both relied in great measure on the analytical geometry of Descartes, the algebra of Wallis, and the methods of maxima and minima of Fermat, to mention but a few of the contributions which made the stage ready for the discovery of the calculus.

Newton's *magnum opus*, insofar as the world is concerned, is his *Principia Mathematica*. This book elaborates the law of universal gravitation, according to which bodies attract each other in direct proportion to their masses and in inverse proportion to the square of the distance between them. It is the first complete treatise on celestial mechanics in which the major known facts were accounted for.

Now, the universe was under law, and a very simple law at that. With one broad stroke of genius, a new era was ushered in; man no longer had to invent special hypotheses to explain planetary motion, nor need he endow the planets with "special intelligences" to direct them in their paths. Considerations of "weight and measure," the fundamental three Newtonian laws of motion, and the law of universal gravitation, were sufficient to explain the hitherto unsolved mysteries of the universe. Small wonder that the succeeding century had such great veneration for Isaac Newton, that Alexander Pope was able to write:

> *Nature and Nature's law lay hid in night,*
> *God said, Let Newton be, and all was light.*

Newton's achievement was based on

the work of predecessors. The immediate past had produced the analytical geometry of Descartes and Fermat, the algebra of Oughtred, Harriot, and Wallis, Huygens' discovery of centrifugal forces, Kepler's laws of planetary motion, Galileo's law of falling bodies, and the law of the composition of velocities—to mention but a few of the ingredients present and waiting for the grand Newtonian synthesis.

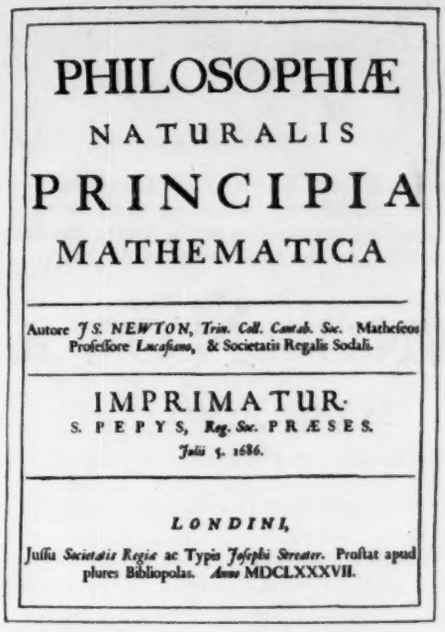
One of the greatest debts of Newton to his predecessors was that which he owed to Galileo. Not just for his laws of motion and mechanics, but rather for a new attitude. Prior to the time of Galileo, it had been generally agreed that there was a difference between sublunary and celestial matter. The matter of the heavens, of the moon, the sun, the planets, and the stars, was thought to be crystalline perfect, immutable and unchangeable. But Galileo's telescope had shown him that the opposite was more truly the case. The sun has spots and rotates like the earth. The moon is uneven in surface, covered with mountains and valleys like the earth. Venus has phases and is like the moon. Jupiter has moons and is in this respect like the earth. The planets shine by reflected light, not by light of their own, and are thus like the earth and the moon. As a result, Galileo showed the essential uniformity of all matter and was thus led to the conviction that it is as "dignified" to study the laws governing the motion of a falling stone as those governing the movement of the celestial bodies. Further, since all matter is the same, the laws must certainly be the same laws. Nature, according to Galileo, is dominated by the word *necessity*; hence, its laws must be mathematical.

Newton's accomplishment was to give a formal statement of this credo of Galileo. He showed that the laws of motion applies equally to terrestrial and heavenly bodies, that the force which keeps the moon in her perpetual orbit is the same force which gives its curvature to the flight of a stone on the earth.

Every man makes errors. Just as Newton did not foresee achromatic lens combinations, so did he err with regard to the nature of space. Newton held that space, like time, was absolute: there was a fixed space and a fixed immutable center of gravity of the universe. The theory of relativity has altered our notions of space and time and we no longer hold with Newton. Einstein has demonstrated that the laws of dynamics can be given a more general form than that enunciated by Newton. In keeping with the times, J. C. Squire has added the following lines to Pope's couplet:

But not for long, for Devil howling Ho
Let Einstein be, restored the status quo.

AND then, when Newton was at the height of his scientific career, he abandoned the pursuit of science to become a public servant. The third period of his life began when he was, at his own request, appointed Warden of the Mint. Under his supervision, the great undertaking of the total re-coinage of English money was begun and completed. When this had been done, in


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA

Autore *J. S. NEWTON, Trin. Coll. Cantab. Soc.* Matheseos Professore *Lucasiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

LONDINI,
Juſſu *Societatis Regiæ* ac Typis *Joſephi Streater*. Proſtat apud plures Bibliopolas. *Anno* MDCLXXXVII.

Title page of the first edition of the "Principia" (reproduced, slightly retouched, from the copy in the Boston Public Library). It bears the "Imprimatur" of Samuel Pepys, the learned diarist, who as president of the Royal Society had to declare that he thought "this book fit to be printed."

1699, Newton was promoted to be Master of the Mint. In 1703, he was elected president of the Royal Society, of which he had been a Fellow since 1672.

He took his duties at the Mint very seriously. His own mood is best revealed by a letter in which he rebuked Flamsteed. "I do not love to be printed on every occasion," he wrote, "much less to be dunned and teased by foreigners about mathematical things, or to be thought by our people to be trifling away my time about them when I should be about the King's business."

But this third period of Newton's life was not wholly barren of scientific achievement. It not only witnessed the publication of the *Opticks* (1704), but was marked by various discoveries. With one of these, there is associated a story which can never be too well known, and which illustrates the magnitude of Newton's creative ability better than any description could.

In the Leipzig *Acta* for June, 1696, Johann Bernoulli, one of Europe's foremost mathematicians, published a challenge problem addressed "to the most acute mathematicians of Europe." The problem was to find the curve between two points not in the same vertical line along which a body falling by its own weight shall descend in the least possible time. Newton received two copies of the problem at four o'clock in the afternoon on January 26, 1696/7. Before he went to bed that night, he had not only solved the problem and found the curve in question to be one called the *brachistochrone*, but had completed the problem by generalizing it.

In the course of time, Newton's result was printed, although anonymously. When it came to the hands of the challenger, he immediately recognized the authorship, declaring with interjection, "*Ex ungue leonem!*" A mere "claw" sufficed to reveal the "kingly creature."

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NEW COMET FOUND

On December 12th, Dr. Fred L. Whipple discovered a new comet on a patrol-camera plate taken on December 7th at Harvard's Oak Ridge station. On December 8th at $5^h\ 38^m$ U.T., it was about six degrees south of Jupiter, at R.A. $7^h\ 50^m$, Dec. $+15°.4$, with a daily motion of $1^m\ 40^s$ eastward and $19'$ northward.

Dr. Whipple detected the comet's image on as many as 20 patrol plates as far back as the 1st of November, when the object was fainter than the 12th magnitude, but it does not show on good quality plates taken during October. Positions obtained are sufficient for computation of a good orbit.

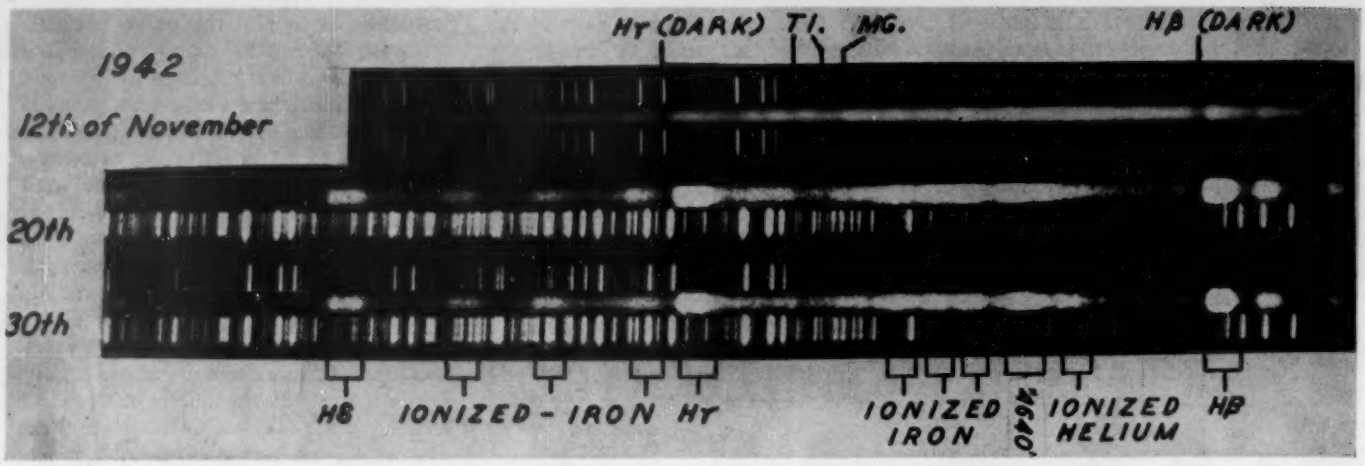


Fig. 1. Each of the three strips is a spectrum of Nova Puppis in the blue-violet region, with the bright-line spectrum of an iron spark above and below it (except on the middle strip, when one spark failed to work). Note the progressive fading of the star's continuous spectrum, and the increasing prominence of the bright bands—the absorption lines are practically gone in the lowest spectrum.

OBSERVING NOVA PUPPIS

BY DEAN B. MCLAUGHLIN

Observatory of the University of Michigan

NOVAE are no respecters of persons. They reserve the right to occur in the most inconvenient places in the sky, and at the most inconvenient seasons. And they make a point of doing tricks of quick-change artistry when nobody is looking. Nova Puppis could have been more inconvenient in just one way—it could have been farther south.

The account of the discovery by several observers has been given in the December issue of *Sky and Telescope*. Here at Ann Arbor, Dr. A. D. Maxwell's observation on the morning of November 11th was the first news we had of the star, and it was too late to get spectrographic observations that morning. The Harvard telegram came a few hours later. It was a relief to learn eventually that spectra were obtained elsewhere. The Yerkes photographs show that the spectrum on Armistice Day was very little different from that which we recorded the next morning.

The first night of observing a nova is always a hectic session. This one was particularly so. The low altitude involved very great loss of light by absorption in the earth's atmosphere, and because of the long path of the light through disturbed air, the seeing was quite poor. The large, wavering star image appeared all over the polished jaws of the spectrograph slit, and only a small fraction of the light really entered the slit. The only way to judge the proper exposure time was to make a trial, develop it while the next exposure was being started, and continue in this hand-to-mouth manner all the time the nova was within reach. Hence the observing was a two-man job during the first several mornings, and the labor was divided between Dr. Maxwell and myself.

Until we actually tried it out, we were not quite sure the 37-inch reflector could be turned that low in the south, or that the observer could reach the eyepiece with which he was to view the slit and the star image. Speculatively, it was proposed that we might solve the problem by poising ourselves hummingbird-fashion above the eyepiece, or that a "sky-hook" would come in mighty handy. Fortunately, our tallest ladder was tall enough, though near the end of each night's observing, when the star was west of the meridian and the spectrograph correspondingly high in the air, the job of guiding became somewhat strenuous, to put it mildly.

The spectrum, as recorded on the morning of November 12th, is reproduced as the top strip of Figures 1 and 2, for the photographic (blue-violet) and visual (red to green) region, respectively. The star was then approximately at maximum brightness, about magnitude 0.6. The spectrum showed bright bands of hydrogen and ionized iron, but these did not stand out strongly above the continuous spectrum. Much more conspicuous were the dark lines on their edges of shorter wave length. In addition, there were dark lines of ionized titanium, magnesium, and silicon, and a line of neutral oxygen, wave length 6155 angstroms, which is often found in the spectra of novae, though not in normal star spectra. All of the dark lines were shifted toward the violet by an amount corresponding to a velocity of approach of about 700 miles per second.

The interpretation of this type of spectrum is no longer the mystery that it was a few decades ago. The bright bands represent glowing gas which is being shot from the star in all directions, and their width is caused by the different speeds of approach and recession of different parts of the cloud. If the gas were stationary, there would be *narrow* bright lines instead. The dark lines represent the outer layers of the approaching side (that is, the nearer side) of the cloud of gas; these outer layers absorb the bright light of the gases directly behind them. The continuous spectrum originates in the denser inner part of the expanding cloud, while the original star is far inside, and is completely hidden by the surrounding atmosphere which rushes outward in all directions. The pattern of spectrum lines—strong hydrogen, ionized iron and magnesium, and so on—indicates conditions like those of a star of perhaps class A5, with a temperature (for the visible part of the cloud) of about 10,000 degrees absolute.

The plates taken that first morning were not well exposed in the extreme violet (beyond the left end of Figure 1). On the second and third mornings, excellent plates were obtained. An important region of one of these is shown in Figure 3. The very *narrow* dark H and K lines are produced by absorption of light by calcium atoms all along the path of the light from the nova to the earth. The strength of these lines has been proven to be at least a rough indication of distance, and a preliminary estimate gives a distance of 1,600 light-years. To appear as bright as it did at maximum, the nova must then have been at least 150,000 times as bright as the sun. A maximum brilliance about one third of this is more frequent. Undoubt-

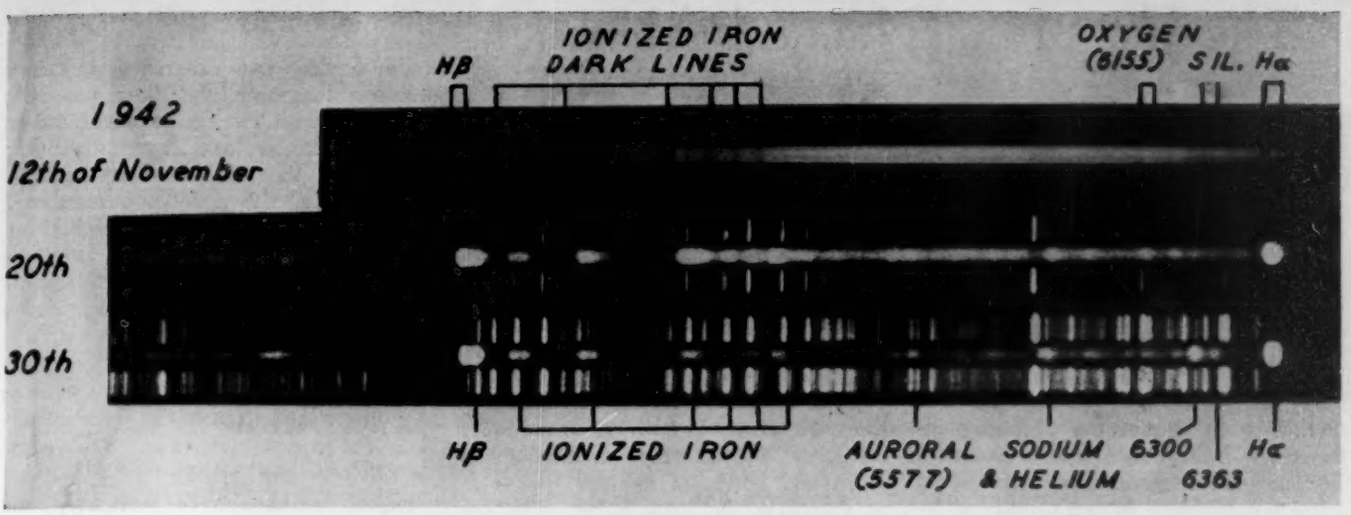


Fig. 2. The red-green region of the spectrum of Nova Puppis, with comparison spectra of an iron spark and a neon tube (except in the upper spectrum, when the neon tube was not connected).

edly, this is one of the more luminous of the common novae; its spectrum shows clearly that there is no basis for suspicion that it is a supernova. Before outburst, however, it must have been much fainter than most recorded pre-nova stars, for it has been reported that no star as bright as the 17th magnitude appears in that position on Harvard plates. This would make it less than 1/50 the sun's brightness before the outburst.

During the next several days, Ann Arbor weather established an unbelievable record for November. For nine mornings in succession it was possible to get exposures, and on only one occasion did the weather really spoil the results. On the second morning a "hopelessly cloudy" sky cleared off just as the nova came into observable position. On the eighth night the exposure was stopped a little short of its intended length when heavy fog billowed up over the dome.

But the ninth morning (November 20th) was the one that looked as if it would be a total loss—until the plate was developed. The weather had warmed suddenly; the humidity was extremely high, and on opening up it was found that moisture had condensed *in pools* on the cold mirror. There was only one chance, and it had to be taken; I wiped the mirror dry in 20 minutes, with absorbent cotton. A silver coat would never have survived the treatment, but the aluminum could take it. By that time the sky was covered with clouds, but an exposure through the occasional clear openings gave a good record of the blue-violet region. The star had by this date faded to about magnitude 3.2.

During the nine-day series of observations (November 12th to 20th), some conspicuous changes occurred in the spectrum. These can be seen by comparing the second strips of Figures 1 and 2 with the first. Most evident of all is the fading of the continuous spectrum, so that the bright bands (especially Hα) stand out very strongly. This loss of continuous spectrum results from a reduction of the amount of material that is being erupted from the star, so that the opaque region of the expanding cloud does not extend so far out from the center, and its effective area is much reduced. The bright bands, on the other hand, originate in the main body of gas which had reached a distance from the star of some 500 million miles, or a greater distance than that of Jupiter from the sun. These gases are now highly transparent, except for the fact that their outer layers on the side nearest the earth (that is, the most rapidly approaching part of the cloud) are able to absorb their characteristic lines. So the bright bands are still flanked by dark lines on their violetward sides.

The expanded gas must have suffered some cooling, for during the interval November 12th-18th, sodium lines, both bright and dark, made their appearance. Their absence earlier meant that the temperature was high enough to ionize all the sodium, so that it could not produce its familiar yellow lines. Another change, which is evident only when one knows just where to look, is the first appearance of the green auroral line of oxygen, and two other lines of the same element at wave lengths 6300 and 6363 angstroms. These are lines of the forbidden type, whose origin (at least in any considerable strength) is possible only at low densities, such as that of the upper atmosphere of the earth, or in the highly rarefied shell of gas around a nova.

After November 20th, although we were always on hand just in case, we did not even glimpse the star once, until the morning of the 28th, when the clouds broke just long enough to permit us to get a very weak exposure that showed only the strongest emission bands. But this at least was something; it showed that the bands had developed a *minimum* of strength at their centers, as if more gas were coming toward and going away from the earth than the amount that was moving out at the sides. This phenomenon is one of the unsolved enigmas of the nova spectrum; almost every nova has shown a somewhat similar effect, but the obvious interpretation just mentioned is difficult to believe, as it seems quite improbable that the directions of eruption of gas would always be so systematic, rather than wholly random.

At last, on the morning of November 30th, we got good plates of both the photographic and visual regions. The star was then about 5th magnitude. Further conspicuous changes had occurred in the spectrum. The continuous spectrum had become still weaker, and the absorption lines had almost disappeared. Several new emission bands had emerged. Most conspicuous of these was the 4640 band, due to doubly ionized nitrogen in the expanding atmosphere close down around the star.

Other bright bands originated in the

(Continued on page 23)

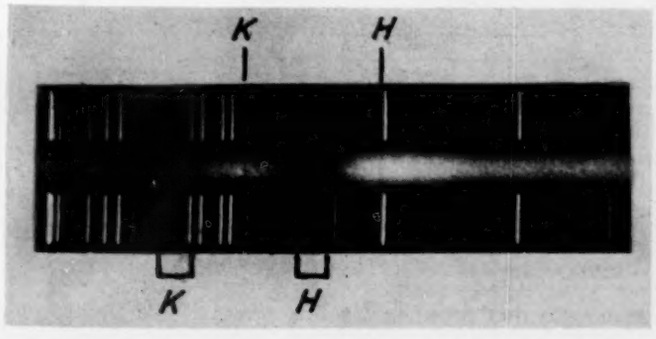


Fig. 3. Labeled at the top are the narrow dark lines indicating absorption by interstellar calcium over about 1,600 light-years. Labeled at the bottom are calcium absorption bands in the expanding shell of gas.

The Use of the Nautical Almanac in Practical Navigation

By Fred L. Whipple

Harvard College Observatory

In a previous article, Dr. Fletcher G. Watson has described the geometrical principles of navigation; and in another, Messrs. Brandon, Bailey, and Willis have discussed the use of the sextant. Two practical problems remain: first, how to extract the necessary information from the *American Nautical Almanac*, and second, how actually to solve the problem of one's position by means of modern tables for the purpose. These two problems together constitute what is known as *working a sight*. We shall discuss the first in this article, and leave the second for a later issue.

In working a sight for a line of position, the navigator starts with the following information:

1. The measured sextant altitude (h_s), above the apparent horizon, of a celestial body such as the sun, moon, a planet, or a star, at a given watch time (W). Usually two or more sights are made in rapid succession and the means of both altitude and time are used.

2. The index correction (IC) or zero-point correction to the sextant.

3. Height of eye above sea level. With a bubble sextant, the height of eye does not enter the problem, but other corrections do enter when observations are made from an aircraft (see last month's article). We shall here consider in detail only observations made with the standard marine sextant.

4. The correction (C—W) of the watch to the chronometer.

5. The chronometer error (CE), which, when applied to the chronometer reading, will give Greenwich civil time (GCT). The chronometer usually reads GCT, except for its error, which is determined by radio signals. The watch will usually read zone time, corresponding at sea to standard time on land, so that C—W will be an integral number of hours except for a small setting error.

6. The dead-reckoning (DR) position, latitude and longitude, of his ship at the time the sight is made.

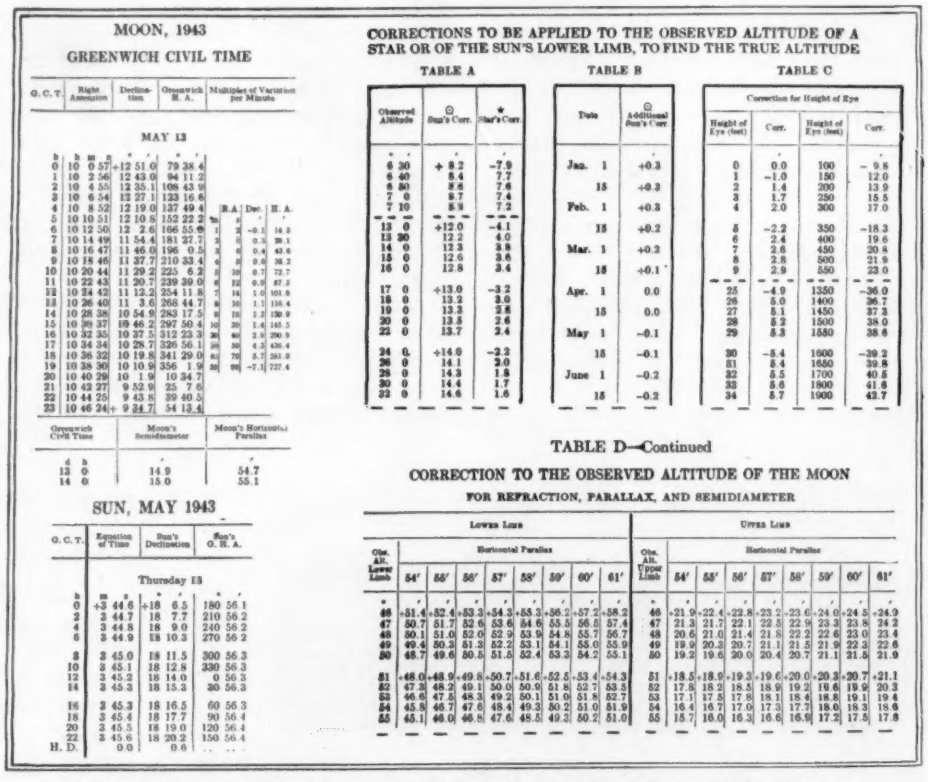
From these data, the navigator must derive a line of position to be plotted on his chart, a straight line upon which the actual position of the ship lies. If sights of two celestial objects in different parts of the sky are made nearly at the same time, the lines of position will cross, and a *fix* is obtained at the point of intersection. A fix represents the best known position of the ship at that instant.

Suppose now that the navigator of our good ship *Namedeleted*, on an uncertain mission off the Atlantic Coast, shoots the lower limbs of the sun and moon during the late afternoon of Thursday, May 13, 1943. His fundamentally observed data, after average values of the altitudes and times have been obtained, are starred in the work forms. In both sights the index correction, watch correction, chronometer error, and height of eye are the same, as shown in the work forms. The DR position at 17–34 is longitude 65° 32′ W, and latitude 42° 08′ N. The vessel's course is 270 (due west) and its speed is 20 knots, so the DR position at 17–43 is in longitude 65° 36′ W.

Note that we adopt a zone time 4^h less than Greenwich time at a DR longitude about 65° west of Greenwich. Time, longitude, and hour angle are all intimately connected and may be measured either in hours, minutes, and seconds of time ($^h\ ^m\ ^s$) or degrees, minutes, and seconds of arc (° ′ ″). In a complete circle of 360 degrees, there are 24^h, so that $1^h = 15°$, $1^m = 15'$, and $1^s = 15''$. Thus a longitude of 65° 36′ W corresponds to $4^h\ 22^m\ 24^s$ W. In navigation, longitude and hour angle are ordinarily measured in degrees. Hence, between longitude 52°.5 W and 67° .5 W, corresponding to longitude $3^h\ 30^m$ W to $4^h\ 30^m$ W, the time of the 60th meridian is used, that is, the +4 zone, where the Greenwich time is 4^h greater than the zone time. Difference of longitude equals the difference in time, because longitude and time are both measured with respect to meridians on the earth. In east longitudes, the Greenwich time is less than the zone time; hence, the zones are numbered −1, −2, and so on, for each hour of east longitude. The mnemonic, *longitude west, Greenwich time best; longitude east, Greenwich time least*, provides a salty mental preservative.

In navigational problems the watch zone time is corrected as well as possible for errors and transferred immediately into Greenwich civil time. The reason is obvious; the positions of the astronomical bodies change with time and must be predicted in advance. A time clearinghouse had to be set up, and the Greenwich meridian was chosen by international agreement. Almanacs give the positions of the sun, moon, planets, and stars, at intervals of GCT. Once our zone time has been changed to GCT, we have only to interpolate in an almanac to find the position of a specified celestial object.

In the first columns of the work forms, the watch times are corrected and changed to GCT. The application of the corrections C—W and CE are obvious. One has only to note carefully which day it is in Greenwich. In west longitudes, the Greenwich date will be the same as our local date if the addition of C—W does not produce a GCT in excess of 24^h. If the GCT exceeds 24^h, we subtract 24^h from it and the Greenwich date is a day later than our local date. Similarly, in east longitudes we



MOON, 1943

GREENWICH CIVIL TIME

G. C. T.	Right Ascension	Declination	Greenwich H. A.	Multiples of Variation per Minute
	MAY 13			
h	h m s	° ′	° ′	
0	10 2 57	+12 51.0	79 38.4	
1	10 2 56	12 43.0	94 11.2	
2	10 4 55	12 35.1	108 43.9	
3	10 6 54	12 27.1	123 16.6	
4	10 8 52	12 19.0	137 49.4	
5	10 10 51	12 10.8	152 22.2	
6	10 12 50	12 2.6	166 55.0	
7	10 14 49	11 54.4	181 27.7	
8	10 16 47	11 46.0	196 0.5	
9	10 18 46	11 37.7	210 33.4	
10	10 20 44	11 29.2	225 6.2	
11	10 22 43	11 20.7	239 39.0	
12	10 24 42	11 12.2	254 11.8	
13	10 26 40	11 3.6	268 44.7	
14	10 28 38	10 54.9	283 17.5	
15	10 30 37	10 46.2	297 50.4	
16	10 32 35	10 37.5	312 23.3	
17	10 34 34	10 28.7	326 56.1	
18	10 36 32	10 19.8	341 29.0	
19	10 38 30	10 10.9	356 1.9	
20	10 40 29	10 1.9	10 34.7	
21	10 42 27	9 52.9	25 7.6	
22	10 44 25	9 43.8	39 40.5	
23	10 46 24	+ 9 34.7	54 13.4	

Greenwich Civil Time	Moon's Semidiameter	Moon's Horizontal Parallax
d h	′	′
13 0	14.9	54.7
14 0	15.0	55.1

SUN, MAY 1943

G. C. T.	Equation of Time	Sun's Declination	Sun's G. H. A.
	Thursday 13		
h	m s	° ′	° ′
0	+3 44.6	+18 6.5	180 56.1
2	3 44.7	18 7.7	210 56.2
4	3 44.8	18 9.0	240 56.2
6	3 44.9	18 10.3	270 56.2
8	3 45.0	18 11.5	300 56.3
10	3 45.1	18 12.8	330 56.3
12	3 45.2	18 14.0	0 56.3
14	3 45.3	18 15.3	30 56.3
16	3 45.3	18 16.5	60 56.3
18	3 45.4	18 17.7	90 56.4
20	3 45.5	18 19.0	120 56.4
22	3 45.6	18 20.2	150 56.4
H. D.	0.0	0.6	

CORRECTIONS TO BE APPLIED TO THE OBSERVED ALTITUDE OF A STAR OR OF THE SUN'S LOWER LIMB, TO FIND THE TRUE ALTITUDE

TABLE A

Observed Altitude	☉ Sun's Corr.	★ Star's Corr.
° ′	′	′
6 30	+ 8.2	−7.9
6 40	8.4	7.7
6 50	8.6	7.6
7 0	8.7	7.4
7 10	8.9	7.2
13 0	+12.0	−4.1
13 20	12.2	4.0
14 0	12.3	3.8
15 0	12.6	3.6
16 0	12.8	3.4
17 0	+13.0	−3.2
18 0	13.2	3.0
19 0	13.3	2.8
20 0	13.5	2.6
22 0	13.7	2.4
24 0	+14.0	−2.2
26 0	14.1	2.0
28 0	14.3	1.8
30 0	14.4	1.7
32 0	14.6	1.6

TABLE B

Date	☉ Additional Sun's Corr.
Jan. 1	+0.3
15	+0.3
Feb. 1	+0.3
15	+0.2
Mar. 1	+0.2
15	+0.1
Apr. 1	0.0
15	0.0
May 1	−0.1
15	−0.1
June 1	−0.2
15	−0.2

TABLE C

Correction for Height of Eye			
Height of Eye (feet)	Corr.	Height of Eye (feet)	Corr.
	′		′
0	0.0	100	− 9.8
1	−1.0	150	12.0
2	1.4	200	13.9
3	1.7	250	15.5
4	2.0	300	17.0
5	−2.2	350	−18.3
6	2.4	400	19.6
7	2.6	450	20.8
8	2.8	500	21.9
9	2.9	550	23.0
25	−4.9	1350	−36.0
26	5.0	1400	36.7
27	5.1	1450	37.3
28	5.2	1500	38.0
29	5.3	1550	38.6
30	−5.4	1600	−39.2
31	5.4	1650	39.8
32	5.5	1700	40.5
33	5.6	1800	41.6
34	5.7	1900	42.7

TABLE D—Continued

CORRECTION TO THE OBSERVED ALTITUDE OF THE MOON FOR REFRACTION, PARALLAX, AND SEMIDIAMETER

Obs. Alt. Lower Limb	Lower Limb: Horizontal Parallax 54′	55′	56′	57′	58′	59′	60′	61′	Obs. Alt. Upper Limb	Upper Limb: Horizontal Parallax 54′	55′	56′	57′	58′	59′	60′	61′
°	′	′	′	′	′	′	′	′	°	′	′	′	′	′	′	′	′
46	+51.4	+52.4	+53.3	+54.3	+55.3	+56.2	+57.2	+58.2	46	+21.9	+22.4	+22.8	+23.2	+23.6	+24.0	+24.5	+24.9
47	50.7	51.7	52.6	53.6	54.6	55.5	56.5	57.4	47	21.3	21.7	22.1	22.5	22.9	23.3	23.8	24.2
48	50.1	51.0	52.0	52.9	53.9	54.8	55.7	56.7	48	20.6	21.0	21.4	21.8	22.2	22.6	23.0	23.4
49	49.4	50.3	51.3	52.2	53.1	54.1	55.0	55.9	49	19.9	20.3	20.7	21.1	21.5	21.9	22.3	22.6
50	48.7	49.6	50.5	51.5	52.4	53.3	54.2	55.1	50	19.2	19.6	20.0	20.4	20.7	21.1	21.5	21.9
51	+48.0	+48.9	+49.8	+50.7	+51.6	+52.5	+53.4	+54.3	51	+18.5	+18.9	+19.3	+19.6	+20.0	+20.3	+20.7	+21.1
52	47.3	48.2	49.1	50.0	50.9	51.8	52.7	53.5	52	17.8	18.2	18.5	18.9	19.2	19.6	19.9	20.3
53	46.6	47.5	48.3	49.2	50.1	51.0	51.8	52.7	53	17.1	17.5	17.8	18.1	18.4	18.8	19.1	19.4
54	45.8	46.7	47.6	48.4	49.3	50.2	51.0	51.9	54	16.4	16.7	17.0	17.3	17.7	18.0	18.3	18.6
55	45.1	46.0	46.8	47.6	48.5	49.3	50.2	51.0	55	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8

These tables are taken from the "American Nautical Almanac" for 1943.

FORM FOR SIGHT -- (ST. HILAIRE)

ZONE DATE May 13, 1943 DR LAT. 42° 08' N

BODY OBSERVED Sun, lower LIMB DR LONG. 65° 32' W

	h	m	s			+	−
W *	17	34	26		IC		1.3
C − W	04	01	29		A	13.6	
C	21	35	55		B		0.1
CE	Fast	2	05		C		5.2
GCT	21	33	50		D		
Tab. GHA	120°	56.4			Sum	13.6	6.6
Corr. 1h	15	00.0		Var. per ___	Corr.	plus	7.0
Corr. 33m	08	15.0		Tab. Dec. +18° 19D	Ht. Eye 28 feet		
Corr. 50s		12.5		Corr. +0.9	h_s *	20°	19.4
GHA	144	23.9		Dec. (d) +18° 19.9	Hor. Par.	h_o	20	26.4

Zone +4; Greenwich Date May 13; IDL; Sun; 17h.6; M; m; Midnight

FORM FOR SIGHT -- (ST. HILAIRE)

ZONE DATE May 13 1943 DR LAT. 42° 08' N

BODY OBSERVED Moon, lower limb DR LONG. 65° 36' W

	h	m	s			+	−
W *	17	43	07		IC		1.3
C − W	04	01	29		A		
C	21	44	36		B		
CE	Fast	2	05		C		5.2
GCT	21	42	31		D	51.5	
Tab. GHA	25°	07.6			Sum	51.5	6.5
Corr. 40m	09	41.9		Var. per. hr. 14° 32.9	Corr.	plus	45.0
Corr. 2m		29.1		Tab. Dec. +9° 52.9	Ht. Eye 28 feet		
Corr. 31s		07.5		Corr. −06.1	h_s *	47°	28.3
GHA	35	26.1		Dec. (d) +9 46.8	Hor. Par. 55'.1	h_o	48	13.3

Zone +4; Greenwich Date May 13; IDL; Moon; 329.8°; M; m

The work forms above simplify the recording of data from the "Nautical Almanac." Similar forms should be used to tabulate the preliminary data in working a sight by any of the standard methods.

may call *C—W* negative (practice varies in this respect). If the zone time, then, is greater numerically than *C—W*, the Greenwich date is the same as the local date; if less, 24h is added before the subtraction is made and the Greenwich date is a day earlier.

The time diagram in the upper center of the work form serves to clarify the problems of time and hour angle. Radial lines on the time diagram represent meridian planes on the earth when one looks toward the north pole along the polar axis. The observer's meridian is labeled *M* at the top of the circle, and longitude increases toward the left or counterclockwise. The Greenwich meridian is drawn in appropriately from the *DR* longitude, the lower half dotted. Next, the direction of the sun is located as follows: Start opposite *M* (at *m*) and measure counterclockwise through an angle equal to the zone or watch time (each hour is 15°, six hours, 90°, and so on). At the longitude where the direction of the sun falls, noon will occur. At the opposite longitude, 180° away, the time will be midnight. Hence, from the international date line (180° from Greenwich) around westward or counterclockwise to the midnight meridian (180° from the sun) the date will be one day later than from the midnight meridian counterclockwise to the international date line. If the midnight meridian does not lie between the observer's meridian (*M*) and Greenwich, then the observer's date and the Greenwich date will be the same. Another memory aid is: *The "tail" of the sun sweeps out the new day.*

One of the quantities we wish to find is the Greenwich hour angle, *GHA*, of the sun. It is represented in the time diagram by the angle from Greenwich westward to the sun, but not precisely enough for our problem. Hence we use the *Nautical Almanac*. On page 17 of the 1943 *Almanac*, we find the sun's *GHA* on May 13th given for two-hour intervals of *GCT* (as shown in the accompanying table). We copy in our work form the value 120° 56'.4 at 20h *GCT*, and then we may turn to the correction table appearing in the sun tables at the end of each month, or simply transform the remaining hours, minutes, and seconds of time into degrees, minutes, and seconds of arc. On the form, 1h becomes 15°, 33m is 8° 15', and 50s is 12'.5. Adding these four quantities, the *GHA* of the sun is 144° 23'.9 at *GCT* 21h 33m 50s, May 13th.

While the *Almanac* is still open to the correct page, we also take out the value of the sun's declination, *d*, at the same instant. At 20h, *d* =+18° 19'.0, but it increases by 1'.2 in the following 2h. Our remaining 1h 33m 50s is about ¾ of 2h, so we add the correction ¾ x 1'.2 or 0'.9 to obtain the declination at the instant of observation.

The corresponding *GHA* and *d* for the moon sight are found on page 73 of the 1943 *Almanac*, also reproduced in the tables. Values are here given for 1h intervals in *GCT*. At 21h the moon's *GHA* is copied out in the work form as 25° 7'.6. The little interpolation table gives a correction of 581'.9 or 9° 41'.9 for an additional 40m, 29'.1 for 2m, and we interpolate 31/60 x 14.5 = 7'.5 for the remaining 31s. In finding *d* the procedure is similar. Always be careful to note, however, whether *d* is increasing or decreasing with *GCT*, and apply a + or − correction accordingly.

While noting the moon data, take out the value of the horizontal parallax (semidiameter of the earth as seen from the moon). It will be needed in correcting the sextant altitude of the moon's lower limb. In our problem, we find the moon's horizontal parallax is 54'.7 at 0h *GCT* on May 13th, and 55'.1 on the 14th. At the time of our sight, it is therefore 55'.1 and is so recorded under the time diagram in the moon sight work form. The moon's position may now be conveniently plotted on the time diagram. The *GHA* of the moon is laid out westward from Greenwich to give the moon's direction with respect to meridians on the earth. Note that in our problem the moon is east of our ship's meridian, as we would have noted in making our sight.

Our next problem is to correct the sextant altitude (h_S) to h_O, the corrected *observed altitude*. The simplest procedure is to write down the corrections in plus and minus columns, to add the columns separately and to apply the difference as a single correction. The index correction (*IC*) is −1'.3 and is thus put in the minus column for both the sun and moon. Likewise, the height of eye correction from Table C (page 295 of the 1943 *Almanac*, reproduced in part in the table) is −5'.2 for a height of 28 feet, regardless of what celestial object is observed. This correction for the dip of the horizon is made to reduce the altitude to the true plane of the sea horizon.

The additional corrections to the sextant altitude of the sun for atmospheric refraction, semidiameter, and parallax are given in Tables A and B of the *Nautical Almanac*, as shown in part in the table.

For a moon sight, the corrections for refraction, semidiameter, and parallax are all combined in Table D. With the horizontal parallax of 55'.1, we find that the correction would be +51'.8 for h_S = 47° and +51'.1 for h_S = 48°. At h_S = 47° 28'.3, the correction is then +51'.5.

In case a sight is made of a star or a planet, the corrections are: 1. *IC*; 2. Table A under the heading *Star's Corr.*; and 3. Table C. Tables B and D are inappropriate, while the horizontal parallax is zero for a star and negligible for a planet. A semidiameter correction is small for planets and may be avoided by bisecting the planetary disk (if seen) with the horizon in making the sight. The use of the *Nautical Almanac* tables of *GHA* and *d* for navigational stars and for the bright planets is described on page 305 of the 1943 *Almanac*. The methods of interpolation can be readily mastered.

We have now obtained the *GHA*, *d*, and h_O for the sun and moon sights, thus completing the use of the *Nautical Almanac* in working sights. Modern methods of solution of the astronomical triangle for lines of position and a fix will be presented in later articles.

When Henry Draper photographed the Orion nebula in 1880, he could hardly have imagined a picture such as this, taken by F. E. Ross with a Ross wide-angle lens and a five-hour exposure. It reveals a mass of nebulosity involving practically the entire constellation.

STARS OF A WINTER NIGHT

By William H. Barton, Jr.

While you are stargazing this month, consider the interesting discoveries which have been made in the January sky, as discussed here and in the Hayden Planetarium.

IN the popular mind, at least, astronomers discover things. A very common question is: "When the new 200-inch telescope is finished, will astronomers discover more planets, or more stars?" A great deal of an astronomer's time, and other people's too, is consumed in routine work—measuring, classifying, calculating, and so on. Only occasionally does he "discover." Yet down through the past three and a half centuries of telescopic astronomy a number of great discoveries have been made. Many of the constellations in the January sky will remind you of some of these dramatic events. Perhaps you may already know many more than we are able to mention here.

If you examine the January sky at about 11 o'clock on the 1st of the month, or 10 o'clock on the 15th, or 9 o'clock on the 31st (all war time) you will be struck with the number of bright stars visible. Low in the southeast is Sirius, the Dog Star, brightest in the heavens. Not far away is Procyon, the little dog star, and just beyond are the Twins, Castor and Pollux. To the southeast, Orion contains two bright stars, Rigel and Betelgeuse, while almost overhead are Capella and Aldebaran. Going down in the northwest is Cassiopeia. Deneb, in the tail of Cygnus, is just disappearing on the horizon.

These stars all form part of a belt of bright stars which extends completely around the sky. Benjamin Apthorp Gould, the American astronomer who first found the difference in longitude between Europe and America by transatlantic cable, noticed this also. In the *American Journal of Science and Arts*, 1874, he traced this belt, supplementing previous work by Sir John Herschel. You, too, can rediscover "Gould's Belt," as astronomers call it even today.

The Dog Star is a historic object. Bessel, nearly 100 years ago (1844), discovered irregularities in its motion which led him to believe it to be a double star. No one, however, could discover the second star visually. But in January, 1862, Alvan Clark was making an 18-inch telescope lens, and in testing the lens on Sirius, Clark's son accidentally discovered the star whose presence had been suspected for nearly two decades. Afterwards, the discovery was confirmed by smaller instruments, and the companion is today famous in its own right as being a typical white-dwarf star. A pint of its extremely dense material would weigh over 25 tons if brought to the surface of the earth.

Even nearer the horizon than Canis Major is an obscure and little-known constellation that broke into the news on November 9th last, when a bright new star was discovered there by Bernhard

H. Dawson, of the Observatory at La Plata, Argentina. Last month's issue and this one tell its story in detail.

Orion, just above Sirius, is well known to stargazers. The three stars in a row, marking the hunter's belt, also mark the celestial equator—the uppermost of the three lies almost exactly on that important circle, so it is practically midway between the celestial poles. Below the belt, in Orion's sword, is the famous nebula, which can be seen easily with a small telescope. The first successful photograph of this object was made by Henry Draper on September 30, 1880. He improved his results in the next two years, but died in the midst of his development of this important branch of astronomy.

A good planetary hunting ground lies above Orion to the east—in Gemini. Tonight you will have no trouble locating Jupiter therein; it is the brightest object in the evening sky (except for the moon when that is visible). In this same region, on March 13, 1781, Sir William Herschel discovered the first new planet to be found since the dawn of history. He thought at first it was a comet, but further study led him to the correct interpretation—a new planet. Herschel called it Georgium Sidus; others dubbed it Herschel; but today it is Uranus. Even when Herschel presented his finding to the Royal Society on April 26, 1781, he thought he had found a comet. In fact, for nearly two years there was doubt as to its true character. The elements of its orbit were first calculated by Laplace and communicated by him to the Academy of Sciences in January, 1783. Beyond doubt, then, it was a new world.

In Gemini also, Clyde Tombaugh discovered still another planet on January 21, 1930. The announcement was made on the 12th of March, 149 years, nearly to the day, after Herschel's memorable discovery. Pluto revolves around the sun so slowly that it has moved in 12 years only to the neighboring constellation of Cancer, appearing there as a yellowish star of the 15th magnitude.

It was in the sky of January that Galileo, in 1610, observed Jupiter and its four bright satellites. It was the 7th of the month when he first found "three little stars, small but very bright, near the planet." They "made him somewhat wonder because they seemed to be arranged exactly in a straight line parallel to the ecliptic." By the 11th, Galileo had observed another and decided they did belong to Jupiter—and the first telescopic moons were added to the visible universe.

Taurus, west of the Twins, is at present the abode of two planets, Uranus and Saturn. The former has almost completed its second trip around the sun since Herschel discovered it. In Taurus, too, on November 6th, Miss L. Oterma, of Turku, Finland, discovered a 13th-magnitude comet moving slowly northward. This is the second comet she has discovered within the year.

Auriga, the pentagonal figure high in the sky, contains the bright star Capella, and near it are three rather dim stars, frequently known as the Kids. They make a small slim triangle, with the base south. The top of this triangle is marked by Epsilon Aurigae, a star whose brightness varies from 3.4 to 4.1 in about 9,900 days, making it the longest period known for a variable. Its variations are the result of periodic eclipses by one of its component stars revolving around and in front of the other. As in the beginning of the case of Sirius' companion, the presence of the invisible star is known, although the star itself cannot be seen. Away back in 1821, Fritsch, a German preacher and amateur astronomer, noticed that Epsilon Aurigae was variable. That was forgotten, however, and the fact was rediscovered by Schmidt in 1848. The star's period is so long, about 27 years, that since then it has dimmed only three times, in 1875, 1902, and 1929.

The invisible companion's true nature was figured out by Gerard P. Kuiper at Yerkes Observatory. This star is a great globe of gas of such a low temperature that it does not glow with visible light, and as yet its infrared light has not been recorded on a photographic plate—but sometime it may be. The average density of the companion of Epsilon Aurigae is very low, so it has to have an enormous size to contain its mass, which is 30 times that of the sun. It is about a million times less dense than air, and about 3,000 times the diameter of the sun. If the sun were placed at its center, Epsilon Aurigae's "surface" would be well outside the orbit of Saturn! The eclipses of its visible primary are not caused by the companion itself, but by a kind of Heaviside layer high in its atmosphere, at a tremendous distance from the center of the star. Compare the dense companion of Sirius with this ethereal companion of Epsilon Aurigae!

THE GRAPHIC TIME TABLE OF THE HEAVENS FOR 1943 is reproduced on the following pages.

Perseus, the next star group west of Auriga, contains the Demon Star, a mysterious variable of ancient vintage. The Arabs no doubt noticed its winking; it also is an eclipsing variable. They called it *El Ghoul*, hence, our present name for it, Algol. Its short period of about two and three quarter days and its noticeable change of brightness make it easy for anyone to observe. On the "Observer's Page" the times of its favorable minima are given for this month.

Marfak, the brightest star in Perseus, is at the end of a large "dipper" composed of seven bright stars. Three of them are in Pegasus, in the Great Square, and the other three are the principal stars in Andromeda. There the hazy spot we now call the Great Nebula was mentioned as early as the 10th century by the Persian astronomer, Sufi. Another recorder was Simon Marius, who saw the nebula on December 15, 1612. He thought it looked like a small cloud, and, through his telescope, like a patch of whitish light seen from a distance through a semi-transparent medium. Halley and Messier also described it. The latter, whose catalogue of nebulae and clusters is famous, reports it as a diamond-shaped nebula two thirds of a degree long and a quarter of a degree wide. He noticed an increase in brilliance toward its center, but did not see any individual stars in it. Sir William Herschel thought it would resolve into stars, and so have others down through the years, but it was not until 1925 that its individual stars were first definitely seen, on photographs taken with the 100-inch telescope on Mt. Wilson.

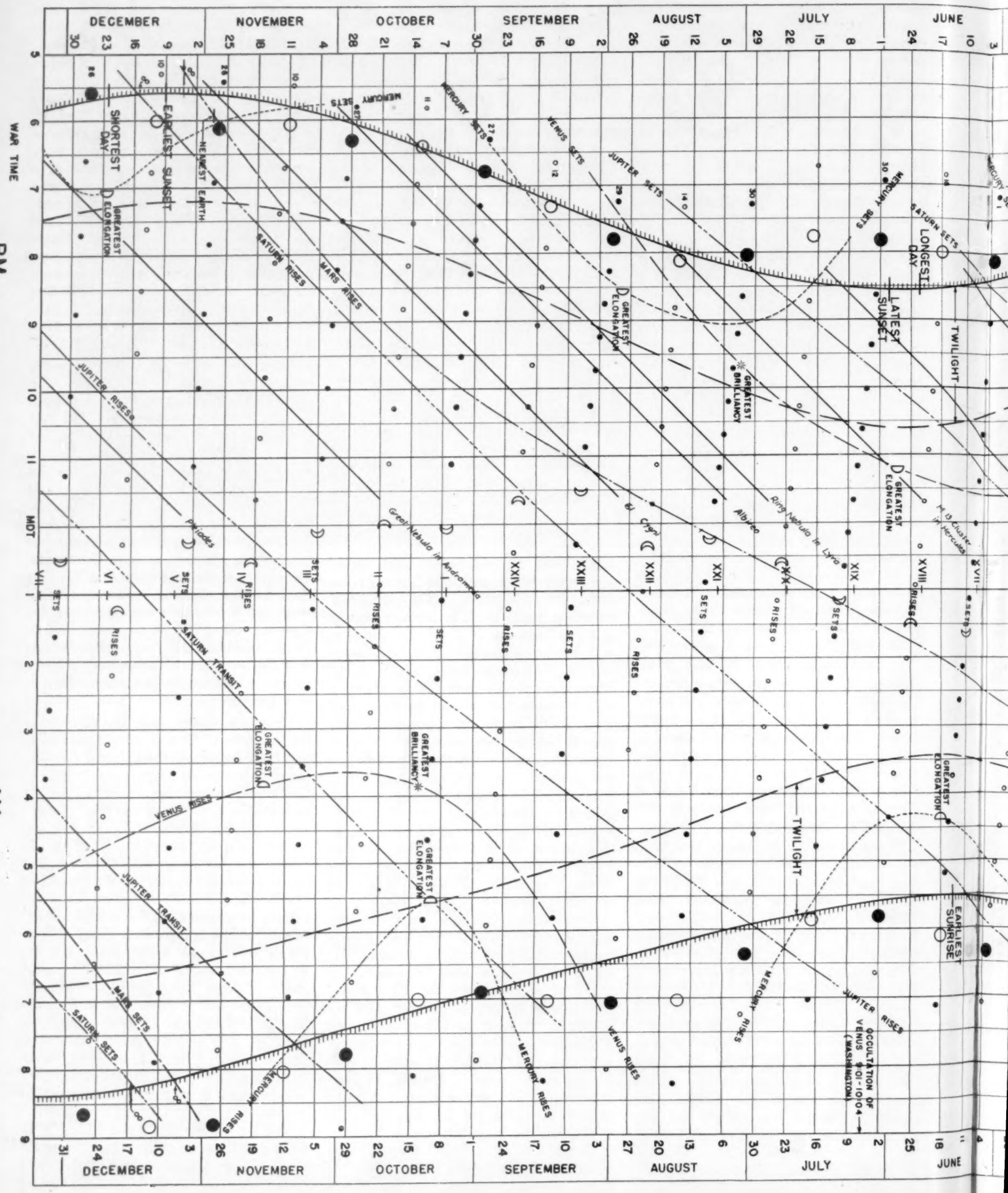
Along the Milky Way to the west, Cassiopeia's W can be easily found. The great Tycho Brahe discovered his famous nova here on November 11, 1572. At first it exceeded Jupiter in brilliance, but it grew brighter than Venus and finally was visible in broad daylight! Then the nova faded and in a year and a half had disappeared from naked-eye observation. But there were no telescopes then, so its subsequent identification has never been positive. It is in Cassiopeia, too, right in the middle of the W, that the fickle star, Gamma, is located. A few years ago it became temporarily brighter than any other star in the constellation, nearly reaching the 1st magnitude. As it is almost constantly changing, it bears watching, for we do not know when it may flare up again.

Cygnus is almost out of the sky, low in the northwest. It was in this constellation that Bessel, in 1838, found the distance to a star, 61 Cygni, and it is here that evidence has been found that might indicate the presence of the first "planet" outside of our own solar family. K. Aa. Strand, research associate at the Sproul Observatory of Swarthmore College, recently presented a paper to the American Philosophical Society in which he noted certain irregularities in the orbital motion of one of the components of 61 Cygni, for it is a visual double star. His interpretation is that a "planet," of mass about 16 times that of Jupiter, circles the component about every five years. Although this mass is extremely small, as stars go, it is still far greater than any planet in our system. More work needs to be done, but if Dr. Strand's discovery is confirmed, it will mark a new era in astronomy.

We have gone along the Milky Way from one horizon to the other. How do they check up—your discoveries and mine?

Graphic Time Table of

PREPARED BY THE MARYLAND



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The Graphic Time Table of the Heavens

while still available may be secured without charge directly from the Maryland Academy of Sciences, 2724 N. Charles Street, Baltimore, Md. Blueprints of the original drawing before reproduction are available at cost—about 35 cents—size 40 x 27 inches.

The Graphic Time Table gives the rising and setting times of the sun, moon, and planets; the beginning of morning twilight and the ending of evening twilight; the times when certain stars and other objects of particular interest cross the meridian (that imaginary line which splits the sky into its eastern and western halves); the phases of the moon, and other interesting astronomical information. To illustrate by an example: The events of the night of January 7th may be found by following the horizontal line for that date across the page from left to right. We find that the sun sets at 4:50 p.m. standard time (5:50 war time); Jupiter rises at 5:00 standard time; while Venus sets at 5:48, and Mercury at 6:21; evening twilight ends at 6:28. The moon sets at 6:34. The Pleiades transit (cross the meridian) at 8:35; Saturn transits at 9:12, as does the Great Nebula in Orion at 10·26. Saturn sets at 4:19; Mars rises at 5:15; morning twilight begins at 5:45, and the sun rises at 7:22.

The dashes on the sunrise and sunset curves are for interpolation on days other than those indicated. Standard time is shown on the top line, and war time at the bottom. Sidereal time at midnight is shown by the Roman numerals down the standard-time midnight line.

The phases of the moon are indicated by the conventional symbols. Small black circles show moonset for the first half of the lunar month, and the small open circles show moonrise from full to new moon.

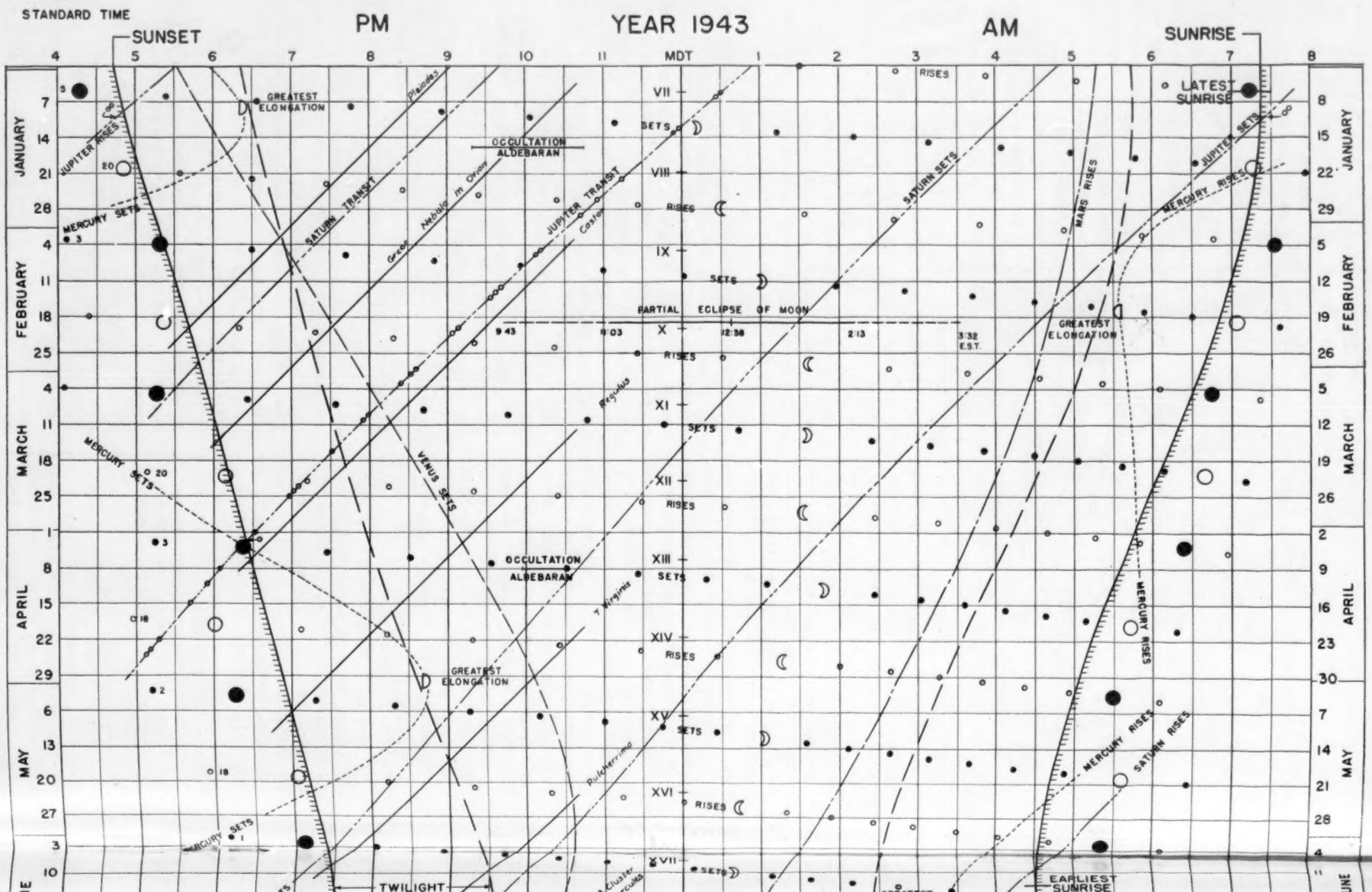
How to Correct for Your Position

As in all almanacs, times of rising and setting of sun, moon, and planets, are absolutely correct for only one point on the earth's surface—for this chart, latitude 40° north and longitude 90° west. However, the observer may easily correct for his own position. Correction for difference in latitude is comparatively minor—it need only be remembered that when members of the solar system are north of the equator, they remain visible longer as we go farther north, and for lesser time as we go farther south.

Correction for the difference in longitude depends only upon the observer's distance east or west of his standard time meridian (which is always an even multiple of 15). Some corrections are tabulated here:

Atlanta	+38	Detroit	+32	New York	− 4
Baltimore	+ 6	Helena	+28	Philadelphia	+ 1
Boston	−16	Houston	+22	Pittsburgh	+20
Chicago	−10	Los Angeles	− 7	San Fr'cisco	+10
Cincinnati	+38	Minneapolis	+13	St. Louis	+ 1
Denver	0	New Orleans	0	Washington	+ 8

All places with plus correction are west of the standard meridian, and the events will occur later. The usual correction of one hour for each standard time zone must also be made to times of eclipses of the moon and transits of Jupiter's satellites, and in the Far West slight corrections must be made to times of moonrise and moonset. For times of occultations and solar eclipses, refer to the "American Ephemeris."



Amateur Astronomers

SOLAR ECLIPSE IN ALASKA

By Leo Mattersdorf

IN ancient Chaldea, the astronomers knew that eclipses recur at intervals of about 6,585 1/3 days. In our calendar this is equivalent to 18 years, 10 1/3 days or 18 years, 11 1/3 days, depending upon the number of leap years between the two eclipses. This interval is known as the saros. Eclipses forming a series of such saros intervals begin as partial eclipses in the north or south polar regions and work their way south or north therefrom. After several returns of the partial phase, total or annular eclipses begin, and after some centuries, the series reaches the opposite polar region, and after more partial phases, disappears. Many of these saros cycles exist at one time, some working their way north, others, south. The whole of a series occupies some 12 or more centuries.

On February 4th and 5th of this year, there will be a total eclipse of the sun. Eighteen years, 11 1/3 days before this date was January 24, 1925, when took place a total eclipse seen by more people of the civilized world than any other in human history. Its path swept across parts of Minnesota, Wisconsin, Michigan, Canada, New York State, reached into New York City, crossed southern New England, and then passed out to sea. Perhaps many of our soldiers, sailors, or marines in Alaska who will be privileged to see the coming obscuration will have seen its predecessor in the series.

The series started in the south polar regions with the partial eclipse of May 27, 933, and will end in the arctic regions in the 22nd century.

In the third of a day which is appended to the 6,585 days of a saros, eclipses move one third of the way around the earth to the west. In 1925, the shadow of the moon first touched the earth in the middle of this continent, in Minnesota. On February 5th (this eclipse begins a day before it ends, since it crosses the international date line) it will first touch the earth near Hingshanchen in Manchuria. It will then cross the Sea of Japan and pass over the Japanese island of Hokkaido. Perhaps when the Nipponese look up at the obscured sun, they will learn how black will be their skies when the planes of a righteous and mighty America come to wreak vengeance and retribution. But let us assure them that when we do come, there will be no enchanting beauty, just a lesson as unforgettable as is the beauty of the eclipse.

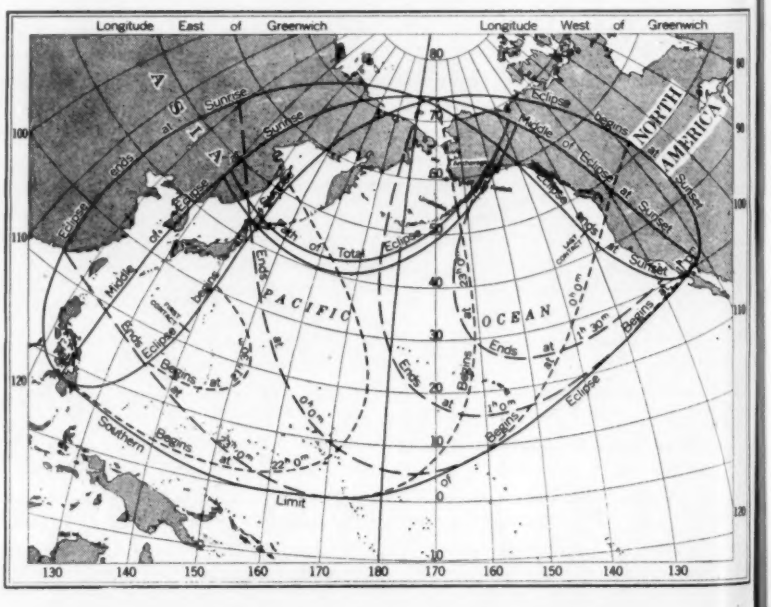
The shadow will leave the land of the so-called Son of Heaven and race across the Pacific. On February 4th, it will pass south of the Andreanoff Islands, where totality will take place at local apparent noon. Then the shadow will run just south of Dutch Harbor, along Shelikof Strait, over part of Kodiak Island, Cook Inlet, streak out across the Chugach and Wrangell Mountains of Alaska, and leave the earth at sunset in the wilds of the northern Yukon Territory, Canada, near the Peel River in the Mackenzie Mountains. The maximum duration at one point of the central line will be about two minutes and 39 seconds—an average for a solar eclipse. This will occur some hundred miles due south of Attu and Agattu, those two famous islands at the end of our Aleutian chain.

Since the partial phases of the eclipse can be observed from all parts of Alaska, from Hawaii, and before sunset from our West Coast states and western Canada, it is well to reiterate an old warning. The partial phases must be viewed *only through smoked glass or a dense negative*, one so dense, in fact, that no terrestrial scene can be viewed through it. Failure to observe this precaution may result in serious injury to the eyes, or even blindness. The total phase will be enjoyed without eye protection, if the observer is fortunate enough to be in the path of the umbra.

What of future total and annular eclipses visible as such in North America—say, for the next 10 or 11 years? On July 9, 1945, the path of a total eclipse will again cross part of the United States. The moon's shadow will first touch the earth at sunrise not far from Boise, Idaho, and then travel northeastward through Montana, Saskatchewan, Manitoba, thence across Hudson's Bay to Greenland, and continue into Europe and Asia.

On September 1, 1951, an annular eclipse (one where the moon's shadow falls just short of the earth so that we see a ring, or annulus) will start west of Winston-Salem, N. C., at sunrise and pass out to sea. On June 30, 1954, will occur an eclipse whose path will be south of and almost parallel to the one of July 9, 1945. Starting in the vicinity of Garfield County, Neb., the moon's shadow will probably cross parts of South Dakota, Iowa, Minnesota, Wisconsin, Michigan, Ontario, Quebec, and Labrador, before passing over the Atlantic Ocean to Europe and Asia. It will not be until August 21, 2017, that a total eclipse will pass squarely across the United States.

Those who have never seen a total eclipse cannot begin to imagine its beauty. In the midst of day, the solar orb is blotted out, and man can see, without instrumental help, the pearly corona. In the darkened daytime sky the stars shine in the firmament, a reminder that these friends are always there, though usually blotted out by the greater glory of the sun. An eclipse knows no wars. The lunar shadow crosses the lands of bitter enemies. But from its beauty, even in time of war, we can gather hope of better things to come, of days when peace and justice shall reign once more.



The partial phases of the solar eclipse next month can be seen from many lands including Hawaii and our West Coast. The times given on this chart from the "American Ephemeris" are in Universal time, which is the same as Greenwich civil time. Note the narrow path of totality.

AMATEUR ASTRONOMERS ASSOCIATION

New York City

Lectures for January will include *Astronomical Photography Without a Telescope*, by Charles H. Coles, chief of the photographic division of the American Museum, on January 6th, and Miss Margaret Harwood, of the Maria Mitchell Observatory, speaking on January 20th on *An Island Observatory: Its History and Work*. Both meetings are at the American Museum of Natural History at 8:15 p.m., and are open to the public.

NEWS NOTES

By Dorrit Hoffleit

FIRST VERMONT METEORITE

It has been estimated that in recent years an average of about 25 meteorites per year are found. Yet in all New England, according to Dr. Fletcher G. Watson (*Between the Planets*), a total of only five had heretofore been recovered. Hence the discovery in August by C. G. Doll, of the University of Vermont, of a five-pound meteorite on Whitcomb Hill, Strafford, Vt., is noteworthy. This is the first meteorite ever to have been found in that state, and is apparently the first New England meteorite not actually seen to fall. On etching it showed the characteristic Widmanstaetten figures. Its dimensions are 5½ x 4 x 2½ inches and it is shaped somewhat like a flatiron.

FELIX DE ROY OF BELGIUM

It is with much regret that we report the belated news of the death of Dr. Felix de Roy in Belgium in May. De Roy was well known to professional and amateur astronomers for his keenness in observing meteors and variable stars. Among his many astronomical activities he was president of the Société d'Astronomie d'Anvers, one of the editors of the *Gazette Astronomique*, president of the commission on meteors of the International Astronomical Union and a member of its commission on variable stars, and, though a Belgian, director of the Variable Star Section of the British Astronomical Association. He was one of Belgium's leading journalists, and held an honorary degree from the University of Utrecht.

In 1932 de Roy came to America both to observe the total eclipse of the sun and to attend the I.A.U. meetings in Cambridge, where he paid an extended visit to the Harvard Observatory. He observed the eclipse from a gyroplane—the first astronomical use of such a machine.

We remember him also as being one of the ablest interpreters at the meetings of the International Astronomical Union, where all astronomers were far from having a common language. He is mourned by his wife and three sons and a host of friends. It is particularly disheartening to realize that starvation in a war-torn country had much to do with the loss of an able man in the prime of his life.

BIZARRE HYPOTHESIS

In a brief note, *Popular Astronomy* reports on an investigation on the "bizarre hypothesis" that the meteor responsible for Meteor Crater in Arizona may have had something to do with the felling of the trees in the petrified forests of northeastern Arizona. Richard Feldman finds a general common orientation for undisturbed tree trunks in each of the three petrified forests, Holbrook, Cameron, and Ganado. The intersections of the three directions for these areas form a triangle including Meteor Crater! Geologists consider his idea fantastic—but nevertheless there is food for thought.

THE EARTH'S EQUATOR

We must apologize for some misleading errors printed last month under the title, "How Round Is the Earth's Equator?" The ellipticity and eccentricity are both quantities representing the "flattening" of an ellipse, the first preferred by geodesists, the second by astronomers. The eccentricity of the meridianal cross-section of the earth is about 1/12, corresponding to the ellipticity of 1/296, the figure erroneously quoted last month—this is the well-known difference of 26 miles between the equatorial and polar diameters of the earth. The eccentricity of the equator, on the other hand, is about 0.007, corresponding to an ellipticity of 0.000024, based on work by Jeffreys. This means that the longest diameter of the equator (which incidentally passes nearly through the longitude of Greenwich!) is about 300 meters longer than the shorter one.

We are much indebted to Walter D. Lambert, of the U. S. Coast and Geodetic Survey, for clearing up the errors and supplying additional facts. He states: "It should be emphasized, however, that the ellipticity gives only a very incomplete expression of the irregularity of the earth's equator, or of its surface in general."

BIG PLANET OR LITTLE STAR?

The system 61 Cygni remains in the limelight, owing to the interest of Dr. K. Aa. Strand, of the Sproul Observatory. Just a year ago he reported in this magazine on the first successful determination of the relative orbit of the parallax-famous double star. (It was the first star whose distance had been reliably determined, by Bessel in 1838.) Last year, Dr. Strand succeeded in showing that the period of revolution of one star about the other of the known pair is about 720 years. Their present separation is about 110 times the distance between the sun and earth, or about 10 billion miles.

Now Dr. Strand finds that very accurate measurements of the positions of the two component stars reveal small periodic deviations from the positions expected on the basis of his orbit. These deviations, called perturbations, can be accounted for on the assumption that the binary is accompanied by a third body. His computations then reveal that the mass of the third body must be about 16 times the mass of Jupiter, or 1/60 that of our sun. This is large in comparison with our solar planets, but small compared to the stars. The lightest stars known have masses greater than 1/10 the sun's.

In a paper given recently before the American Philosophical Society, Dr. Strand makes the suggestion that this invisible companion of 61 Cygni is a planet rather than a star. If so, this is the first instance of the discovery of planetary motion outside our solar system. The object revolves around one of the two components of the double star in a period of five years in a highly eccentric orbit. When the "planet" and the star are closest together, their separation is 65 million miles, or a distance only two thirds that between the earth and the sun.

Note on "Do You Know?"

The quiz column, "Do You Know?" is being discontinued for a while. Watch instead for Dr. L. J. Lafleur's innovation, "Sauce for the Gander," which will appear from time to time in forthcoming issues.

Index Announcement

A title page and working index to Volume I of *Sky and Telescope* is now ready for distribution. It includes author, title, subject and topic references, adding considerably to the usefulness of the year's issues. Because of the increased cost of printing this more elaborate index, a charge of 25c a copy postpaid is made for it, which may be sent in coin or stamps. Please send your orders in promptly. ED.

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METEORITES

By O. C. Farrington

The price of this outstanding book has been reduced to $2.00, including mailing charges. Checks should be made to The Society for Research on Meteorites and sent to the secretary, C. H. Cleminshaw, Griffith Observatory, Box 9866, Los Feliz Station, Los Angeles, Calif.

BEGINNER'S PAGE

Asteroids — Planetoids

By Percy W. Witherell

AT irregular intervals, the "teletype" prints a message at Harvard College Observatory which may arouse some interest if it tells of the appearance of a new comet, or which creates a thrill if a startling discovery like Nova Puppis is recorded. But then, again, the moving object may be "only another asteroid." Harvard College Observatory is the clearinghouse of astronomical discoveries for the Western Hemisphere and Copenhagen is the same for the countries across the Atlantic. These centers immediately relay to other observatories data concerning new finds in the sky. Then the results of the latter's observations are sent back to the original point of discovery as well as to all interested parties. This quick concentration of the eyes of observatories in all parts of the world soon obtains enough data to determine the characteristics that may distinguish the particular object reported. If it is a comet or an asteroid, the orbit may be computed from three observations sufficiently far apart, and we can then tell whether the new traveler is on its first observed visit or is just an old-timer. We can also predict its future positions.

When Uranus was discovered by William Herschel in 1781, 24 German astronomers divided the zodiac among them and began a systematic search for another planet. But it was Piazzi, at Palermo, who discovered, on January 1, 1801, while observing for his star catalogue, an object which moved among the stars like a comet but did not have the hazy appearance usual to comets. Instead, it was starlike, hence the designation, *asteroid*. He carefully observed the object's path for six weeks until illness prevented further watching. On his recovery, he could not find the new planet, as it had moved too close to the rays of the sun.

Thus did the asteroid Ceres, named after the tutelary goddess of Sicily, start the search which has resulted in the discovery of so many hundreds of these *planetoids*, as they are less frequently called. Another term for them is *minor planets*.

So many asteroids subsequently were found (Ceres being the largest) that special institutes were created to keep records of their doings, and the astronomical world as a whole assumed its present rather nonchalant attitude toward them. Although improved electrically operated computing machines and elaborate tables of perturbations simplify the computation of orbits, the task of keeping track of all the known asteroids is huge, especially as the war has interfered with the European astronomers who have previously performed this work.

The news of the discovery of Ceres stimulated the search in Germany. Fortunately, Gauss, the famous mathematician, had proposed a new, simplified method of computing orbits from a few observations. So, on December 31, 1801, von Zach, and on January 1, 1802, Olbers, found Ceres very close to its predicted position. In March, Olbers found a second small planet, now called Pallas. Its orbit was eccentric and inclined to the plane of the ecliptic. This suggested that a search near the intersection of the orbits of the two asteroids and the ecliptic might result in the discovery of other fragments of the possible disruption of a larger body. In 1804, Juno was found by Harding, and in 1807, Olbers located Vesta, the brightest of all that have been discovered.

Then a long period of nearly four decades elapsed without the encouragement of further discoveries. In 1845, Astraea was found by Henoke, and in 1847 three more were brought to light.

In 1891, a new era of search began with a study of trails on photographic plates. The telescope was kept steady on the stars, and the moving asteroids made line images during the exposure. Later, the Rev. Joel H. Metcalf, of Winchester, Mass., invented a method of moving the plateholder so as to keep the average asteroid nearly in one spot on the plate. This results in a longer exposure of an asteroid if one happens to be in the field, so the intensified image of the asteroid is easier to detect. This method has facilitated the discovery of many very faint asteroids.

During an exposure on a field of stars, the motion of an asteroid in its orbit makes it appear as a streak on the plate. In this case, the asteroid is easily found near the center of the field.

At the present, over 1,800 individual asteroids have been reported. As it is difficult, however, to compute orbits precisely from the usual short period covered by the observations that are accurate enough to predict merely a future position, there are many rediscoveries. Nevertheless, over 1,500 asteroids have been named or numbered. The names of goddesses were used at first; then all sorts of places and people were commemorated; but now many asteroids are known only by number designations.

All of the minor planets so far recorded go around the sun in the same direction as the principal planets. Their periods range from less than two years to more than 30, with an average of 4.75. The average inclination of their orbits to the ecliptic is eight degrees, but that of Pallas is 35 degrees. Most of the orbits are between those of Mars and Jupiter, but some cross those of Venus and Saturn.

In size, the larger asteroids range from Ceres, 480 miles in diameter, through Pallas, 300 miles; Vesta, 240; Patroches, 189; Phoebe, 150; Juno, 120; to Achilles, Nestor, Priamus, all 75 miles in at least one dimension. Most of these bodies are even smaller than this, for example, Albert and Alinda are three miles across, and little Hermes is a piece of celestial rock estimated to be less than one mile in diameter.

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GLEANINGS FOR A. T. M.s

By Earle B. Brown

The A.T.M. and the Future

THE amateur in every line has always been an experimenter, willing to devote endless hours of seemingly purposeless toil in pursuit of an idea, and this is just as true of the amateur telescope maker. In these days of wartime commodity restrictions, the A.T.M. might well devote his hobby time to experiments to lay the foundation for many future advancements in telescope construction.

For the mathematically inclined, there are immense possibilities in new types of telescopes. It may be thought that the acme has been reached, but we need only to remember that just the last few years have seen the development of the Schmidt camera and its companion derivatives. Telescopic equipment has been practically revolutionized by these developments. To be sure, the idea is an old one, but the innumerable derivative types are quite new.

There are possibilities of new types of telescopes as revolutionary as the Schmidt—all that is needed is an idea. Of course, the answer which is the Schmidt is self-contained in basic optical equations, but these equations do not solve themselves; the answers must be directed. The writer still feels that there are possibilities in the Schuppman telescope, described in this department in The SKY, September, 1941. A few experiments have shown undesirable features, such as internal reflections, and it remains for some hard-working amateur to show how these may be eliminated.

Probably the most interesting field for experimentation is that of the optical possibilities in the new transparent plastics: Lucite, Plexiglass, and the other methacylate products. These should make ideal material for Schmidt correcting plates, but so far as is known, their possible uses along optical lines have never been properly investigated. For example, would it be possible to make a cheap, satisfactory, parabolic mirror by mounting a thin sheet of Plexiglass in a vacuum cell?

For the mechanical engineer—amateur astronomers are sadly in need of a light telescope mounting which has the necessary rigidity. At present, a good mounting for a 6-inch reflector weighs about 50 pounds. How about making one which weighs only one fifth as much, yet has all the features of the heavier one? Then we could make telescopes which would be portable in more than name. Apparently, the improvement must be in design, not in material. Surely, this problem is not insolvable.

We are in need of a modern Foucault; that is, we need a new method of measuring the curvature of surfaces to very great accuracy. The Foucault test depends too much on individual judgment. The Hartmann test requires too much preparation. The Ronchi test is not sufficiently quantitative. The Gaviola test is too complicated. The Zernicke test is too confusing in theory. There must be some way to measure a finished surface as quickly and easily as we measure a ground surface with a spherometer or a dial gauge.

In these troublesome times, it is important that we keep amateur telescope making from slipping backward under the pressure of more immediately vital things. In anticipation of an increasing tendency in this direction, we discussed matters similar to these in April, 1942. For the future of the amateur telescope making movement, it is well to pause now and then to redefine our motives and to look forward into the future—to consider what we can do now to prepare ourselves for activities after the present social upheaval is over.

SKY-GAZERS EXCHANGE

Classified advertisements accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge, Mass.

FOR SALE: A 6" reflecting telescope, 48" focus, brass tube, finder, two oculars, simple, sturdy equatorial mounting, tripod, mirrors newly aluminized. Price, $135.00 f.o.b. Cambridge. The Telescope Mart, care of Sky and Telescope, Harvard College Observatory, Cambridge, Mass.

BAUSCH AND LOMB projector, screen, and 100 slides and descriptive cards from Yerkes Observatory for sale. Worth $200.00—price $50.00 f.o.b. Also a 6" reflecting telescope, complete, $20.00. Leerman's, 2846 Oakley Ave., Baltimore, Md.

WANTED: mount suitable for 12" telescope. Send drawing or picture with description and price. Clark J. Wells, Coolidge, Ariz.

BINOCULARS REPAIRED: Prism binoculars—field glasses—spotting scopes—telescopic sights—microscopes—resilvering of prisms and mirrors. We repair, overhaul, make replacements, and accurately collimate all foreign and domestic makes of prism binoculars, field glasses, and microscopes.
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PARFOCAL WITHIN

1/4th

OF THE TOLERANCE SPECIFIED

● Illustrated above are the elements of a parfocal ten-inch lens with a focal length of 25 feet. It was specified by the astronomical observatory which ordered it, that the lens should be parfocal for the C and K spectral lines, with a maximum difference of one millimeter (0.039 inch). As produced in the Perkin-Elmer plant the lens was actually parfocal within a quarter of this tolerance . . . one-fourth of one millimeter (0.010 inch).

Today the facilities of our organization for extreme precision of optical manufacturing are among the most urgently needed by our government. Therefore we are, of course, giving these needs our complete attention now. When Victory is won we shall again place our resources at your disposal.

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MANUFACTURERS OF PRECISION LENSES · PRISMS and MIRRORS
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ASTRONOMICAL ANECDOTES

THE STORY OF FREDERICK

ONE year ago, the predicament of Frederic was detailed in this department. Now, through the courtesy of the genial and jovial secretary of the American Astronomical Society, Dr. Dean B. McLaughlin, we can present "The Story of Frederick," or "An Astronomer's Adventure," with apologies to Munro Leaf, and to Gilbert and Sullivan. It was the extracurricular activity of the American Astronomical Society at its 66th meeting, at Yerkes Observatory in September, 1941.

The Story of Frederick

Once upon a time, a long time ago, there was a little boy named Frederick. And he used to sit on the top of a little hill under the open sky and just look at the stars. His mother, who was a frau, came to him one night and said, "Frederick, why do you sit out here in the cold, looking at the stars; why do you not come into the house with us and sit by the fire where it is nice and warm?" But Frederick said, "Oh, no, mother; I don't like to sit by the fire. I just like to sit out here on top of this little hill and look at the stars." So his mother, who was an understanding mother, went away and left him.

Years passed and Frederick grew and grew and grew. And one day he was a man. He decided that all his life he would spend communing with the heavenly bodies. But how? What should he become? He thought he might be an astrologer. So he sought out the astrologers and listened to what they had to say.

ASTROLOGERS' CHORUS

(To the tune of "When the foeman bares his steel," *Pirates of Penzance*)

When astrophysicists lambaste our horoscopes, our horoscopes,
We immediately cast their horoscopes.
And we find in the design of horoscopes, of horoscopes,
There are no forbidden lines in horoscopes.
But they can see no sense in horoscopes, in horoscopes;
They place their confidence in telescopes.
Other fools believe our hash, and we gather in the cash,
We gather in the cash, cash, cash.
Put Venus in her house among the stars
And add a dash of Mercury or Mars,
Capricornus, Sagittarius, the Virgin or Aquarius,
And that's a horoscope.

But Frederick was not interested in money. Oh, no, he loved the stars—not money. So he wandered to the shores of Lake Upheaval. And there, on the shore of Lake Upheaval, he found the Yokels Conservatory. He opened the door a crack and peeked in, and there he saw a gathering of astrophysicists—theoretical astrophysicists, observational astrophysicists—and they were talking and talking. First he listened to the theoretical astrophysicists and then he listened to the observational astrophysicists.

THE MODERN ASTROPHYSICIST

(To the tune of "The modern major-general," *Pirates of Penzance*)

Theoretical: (Solo)

I am the very model of a modern astrophysicist,
I've got a dandy ordinate whatever the abscissa is;
I tell the solar motion from a very few velocities.
I've frequently computed kinematical viscosities.
I'm very well acquainted with the nebular hypothesis,
For lack of time I must omit the proof of quite a lot of this.
I'm cognizant of meanings and especially the hidden ones;
The spectral lines I know the best of all are the forbidden ones.
Concerning the continuum, in fact I've proved a theorem,
And I'm the very model of a modern astrophysicist.

Chorus:

Concerning the continuum, in fact he's proved a theorem
And he's the very model of a modern astrophysicist.

Observational: (Solo)

I am the very model of a modern astrophysicist,
Which properly interpreted refers to an empiricist.
I am no pencil-pushing theoretical astronomer
And I at least can operate a microdensitometer.
I do not keep a crew of half a dozen young subordinates
To photograph my objects and determine their co-ordinates.
From altitude and azimuth I change to equatorial
By simple trigonometry which works, though not vectorial.
And then it should be emphasized, my plates are hypersensitized,
And I'm the very model of a modern astrophysicist.

Chorus:

And then it should be emphasized, his plates are hypersensitized,
And he's the very model of a modern astrophysicist.

But Frederick was a little confused, and he asked what they did and how they did it.

AN OBSERVER'S LIFE IS SUCH A HAPPY ONE

(To the tune of "A policeman's lot is not a happy one," *Pirates of Penzance*)

Observational: (Chorus)

We observers when engaged in our employment (our employment)
Of securing a celestial photograph (photograph)
Are feeling with emulsion an enjoyment (an enjoyment)
Which a theorist can never know by half (know by half);
Our feelings we with difficulty smother (-culty smother)
For our telescopic duties are such fun (are such fun);
Ah, see one bright constellation, then another (then another),
An observer's life is such a happy one! Ah-h-h-
See one bright constellation, then another (then another),
An observer's life is such a happy one (happy one)!

Theoretical: (Chorus)

When observers are engaged in their observing (their observing)
Or maturing their empiric little plans (little plans),
They forget that data long ago assembled (-go assembled)
Are just as good as any modern man's (modern man's).
Their feelings they with difficulty smother (-culty smother)
When opening up the dome at half-past one (half-past one);
Taking one good long exposure, then another (then another),
An observer's lot is not a nappy one! Ah-h-h-
Taking one good long exposure, ther another (then another)
An observer's lot is not a nappy one (nappy one)!

After listening to the arguments on both sides, Frederick was still bewildered, and he asked: "But there are so many stars; which ones do you look at?"

WE HAVE A LITTLE LIST

(To the tune of "Lord High Executioner's song," *The Mikado*)

Observational: (Chorus)

As some night it may happen that a clear sky may come 'round,
We've got a little list, we've got a little list
Of observable fine objects which might well be sought and found
And which never should be missed, which never should be missed.
There are super-super-novae that shoot nebulae about,
And M-dwarfs with absorption and emission lines no doubt,
The siblings and the common pairs, and symbiotics too,
The spirals that with bars appear, and satellites that skew,
And all third bodies which on spoiling elements insist;
They'll none of them be missed, they'll none of them be missed.
We've got them on the list, we've got them on the list
And they'll none of them be missed; we're sure they'll not be missed.

As some night it may happen that a clear sky may come 'round
We've got a little list, we've got a little list
Of observable fine objects which might well be sought and found
And which never should be missed, which never should be missed.
Canopus and the meteors that shatter up on high,
Wolf-Rayet stars and Beta Peg and Nova Persei,
M fifty-two and Gamma Gem, and gadgets to get lat
By sliding Vega past the pole, you tell where you are at;

BOOKS AND THE SKY

THE PRACTICAL ESSENTIALS OF PRE-TRAINING NAVIGATION

W. T. SKILLING AND R. S. RICHARDSON. Henry Holt and Company, New York, 1942. 113 pages. 75 cents.

SINCE it may be assumed that most pre-training navigation in the near future will be taught to youths of high-school age, a manual or textbook dealing with the practical essentials of the subject is very important. Until navigation teachers have been able to pool their experiences with such a course, new books on the subject will vary both in content and emphasis.

The present volume is carefully worded to provide simple and concise explanations of the principles and problems which the future navigator will have to learn thoroughly in advanced courses. It does not aim to present the details, but only the fundamental principles. In some instances, the presentation of these principles might have been developed more fully or with simpler illustrations, thus helping the imagination of the novice to keep abreast of the ideas. The authors have perhaps relied upon the initiative of the teacher to interpret for the student the passages which seem too brief.

Emphasis is laid upon celestial navigation, with a final chapter on the fundamental laws of storms and the types of clouds. Nothing is said about piloting or radio aids. There is an interesting chapter on determining a line of position from eye-estimates which will introduce the student to an application of the principles of the preceding chapters without involving the precision and detailed knowledge required of the advanced student. The preceding chapters on co-ordinate systems, time, and methods for determining a fix are adequate preparation for this chapter.

Two methods for the solution of the astronomical triangle are given. These are the trigonometric formula and the publication H.O. 214. The methods of Dreisonstok and Ageton are mentioned but not described. The trigonometric formula is used for the illustrations given. Although this formula involves the use of logarithms and considerable time, it should be a "working tool" for a navigator, and therefore belongs in a course on the essential principles of navigating.

The chapter on time becomes a bit confusing by the use of GMT and LMT. These terms occur again in later chapters and leave the reader in doubt about the identity between these and GCT and LCT—now universally used.

This is not a textbook for a class which goes beyond the fundamentals. As the problems at the end of the book show, it represents a treatment of the subject without requiring a familiarity with all the difficulties of navigation. Its purpose is to put before the student the basic principles of nautical astronomy.

FRANCIS J. HEYDEN, S.J.
Harvard University

And all strange objects which on spoiling theories insist;
They'll none of them be missed, they'll none of them be missed.
We've got them on the list, we've got them on the list
And they'll none of them be missed; we're sure they'll not be missed.

And the theoretical astrophysicists wanted Frederick to follow them; and the observational astrophysicists wanted him to follow them. They all talked to him, and tugged at him and pulled him.

COME, FRED, AND FOLLOW ME

(To the tune of "Hail, hail, the gang's all here," *Pirates of Penzance*)

Theoretical: (Chorus)
Come, Fred, and follow me,
Truce to observation, try an integration,
Let's bless astronomy
With another theory.
Observational: (Chorus)
Come, Fred, and follow me,
Truce to computation, try an observation,
Let's bless astronomy
With some more photometry.

But Frederick became so confused that he wandered away. And for all I know, he is still sitting on top of the little hill under the open sky, looking at the stars. He is very happy.

R.K.M.

ROEMER AND THE FIRST DETERMINATION OF THE VELOCITY OF LIGHT

I. BERNARD COHEN. The Burndy Library, New York, 1942. 63 pages. 50 cents.

WHEN the telescope was introduced a little over 300 years ago, it enabled observers to see celestial bodies whose very existence had previously been unsuspected. The first of these to be discovered were the four larger satellites of Jupiter. It was noticed that as these satellites or moons revolve around Jupiter, they are eclipsed by its shadow. Observations of the eclipses showed that the periods of revolution are irregular. In an effort to explain the irregularities, Ole Roemer, a Danish astronomer (1644-1710) argued that light required time to pass from the observed luminary to the earth. By thus establishing that light moves at a definite speed, Roemer overthrew the traditional doctrine of the instantaneous propagation of light.

The lively and interesting study under review opens with a summary of the ideas concerning the velocity of light that were entertained by leading scientists and philosophers in Greek antiquity, the Christian and Muslim middle ages, and the formative period of modern thought. From Aristotle to Descartes, a period of 2,000 years, there were but few dissents from the prevailing belief in the instantaneous transmission of light.

The failure of a 17th-century experiment in which a signal was flashed between two observers stationed at a distance from each other was interpreted to confirm the long-standing hypothesis. It was not yet realized that the terrestrial spaces involved were too small to permit observation of the high, though finite, velocity of light.

But Roemer utilized cosmic spaces and astronomical measurements to settle this question. On the basis that the first or innermost satellite of Jupiter is eclipsed at shorter intervals when the earth is approaching Jupiter, and at longer intervals when the earth is receding from it, he predicted in 1676 that this satellite would be eclipsed 10 minutes later than expected. The actual event bore out his forecast. Although his determination of the velocity of light was too low, it was of the right order of magnitude.

Roemer's additional contributions to astronomy and the other sciences, particularly his notable improvements of observational instruments, receive some attention in the present work. A contemporary portrait of him is reproduced; so is a plate showing the transit instrument which he invented. A useful bibliography and index are provided But misprints give evidence of hasty proofreading. The author should bear in mind, moreover, that some of his readers may not have working control of the foreign languages (Latin, French, German) in which the primary sources he quotes from were written. While we are glad to have before us these key passages in the original language, most of us would like to have them accompanied by an English translation. Despite these minor blemishes, however, the book will be widely welcomed, since it relates succinctly and divertingly one of the most important discoveries underlying modern science.

EDWARD ROSEN
College of the City of New York

NEW BOOKS RECEIVED

ATOMS, ROCKS AND GALAXIES—revised edition, *John Stuart Allen and others.* 1942, *Harper.* 719 pp. $3.75.
This is a revised edition of a modern text designed for science-survey courses; it gives basic and correlated material in astronomy, chemistry, geology, and physics. Questions and supplementary reading suggestions close each chapter.

OPTICS AND SERVICE INSTRUMENTS. 1941, *Chemical Publishing.* 128 pp. $1.75.
The first American edition of an English elementary text on optics and optical instruments. It is non-technical, designed for those with no previous scientific training.

THE STARS TELL THE STORY TOO, *Louise Kreischer.* 1942, *Marantha Publishers.* 79 pp. $1.00.
An interpretation, by an amateur astronomer, of the constellations as a record of the Biblical narrative; also of the Great Pyramid at Gizeh as another enduring record of historical and religious events.

SCIENCE REMAKES OUR WORLD, *James Stokley.* 1942, *Ives, Washburn.* 298 pp. $3.50.
This Scientific Book Club selection, written by the former director of Pennsylvania's two planetariums, discusses and explains in popular fashion a number of the new advances in modern science, and their practical applications. Sulfa drugs, plastics, synthetic rubber, glass, are a few of the subjects covered.

THE STARRY HEAVENS IN JANUARY

Tragedy of the Dusky River—The Two Achernars—How Myths Help Students of the Night

By Leland S. Copeland

ERIDANUS, the great dim river, wanders from blue Rigel on Orion's left foot to blue Achernar in the far celestial south. In its long journey, it meanders downward over more than 50 degrees of stellar space. Yet in all of its course it encloses only five stars brighter than the 4th magnitude.

Achernar means the End of the River. (Accent the first syllable and make the *a* long.) Though we northern observers cannot see this brilliant, at least we can find old Achernar, θ, the original terminus of the river, a 3rd-magnitude star just south of the 40th parallel of declination. Navigators call it Acamar.

Eridanus ranks sixth among the largest constellations. Its attractions include N.G.C. 1535, a planetary nebula, 20″ by 17″, which in large amateur telescopes is small, round, bluish, and blurry; two faint galaxies, N.G.C. 1232 and N.G.C. 1300, both northwest of the Tau stars; and 32, a pleasing double, white and yellow, separation 6″.7. This double, which is 330 light-years distant, can be found at $3^h\ 49.3^m$, $-3°\ 15'$.

The Greek poet of the constellations describes Eridanus as a river of tears. To understand this picturesque phrase we must review the dramatic story of a sad autumnal day. The stellar details suggest late October.

Phaeton, son of Phoebus Apollo and fair Clymene, was destined to set the world on fire. He was distressed because the story of his divine origin was doubted by a classmate; so he appealed to his parents. To banish the young man's doubts, Apollo promised him whatever he should choose. Phaeton answered, "Let me drive your chariot for a single day." The sun-god explained that great dangers lurked in the sky—the Bowman's arrows, the Scorpion's claws, the Lion's teeth, and the Crab's pincers. But Phaeton clung to his request.

Delightedly mounting the great chariot, the daring youth hardly heard his father's parting advice, "Don't use the whip; hold the reins taut." The fiery steeds sensed the inexperience and weakness of their driver. Leaving the rutted zodiacal road, they sped northward. Draco grew hot and menacing, Boötes forsook his herd, and the Great Bear longed for a forbidden ocean bath.

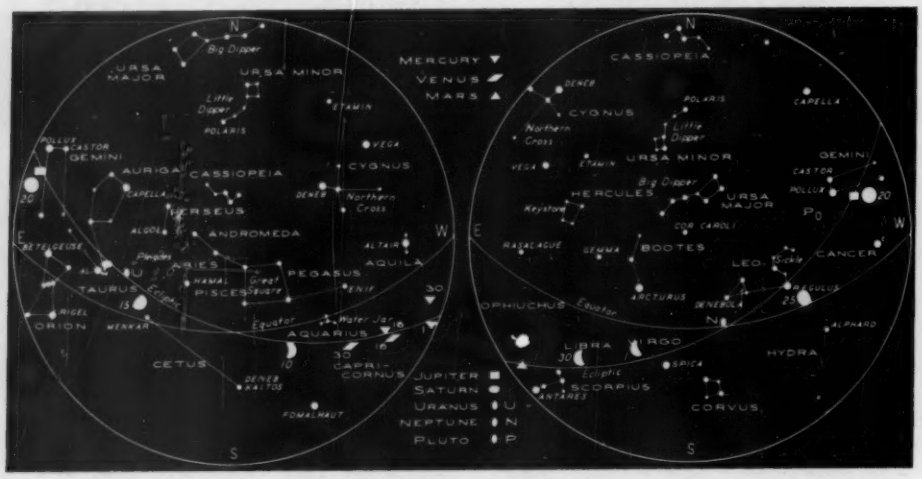
Shortly before noon the chariot, swaying southward, reached Libra, then known as the Scorpion's claws. These horrible tentacles so frightened Phaeton that he dropped the reins. The runaways dashed closer to the earth. Snow melted on high mountains, woodlands burst into flame, and rivers became dry. Responding to a protest from Mother Earth, Zeus with a thunderbolt knocked Phaeton from the car. Hair on fire, the young man shot like a meteor into Eridanus, which the Romans identified as the Po.

So deeply were Phaeton's three sisters distressed by his death that the gods transferred them into poplars and placed them beside Eridanus. Their tears, falling into the stream, became amber drops—a reference to the amber commerce once carried on at the Po's mouth.

"Wait a moment," you comment. "The sun travels only 30 degrees a month. It cannot be in several constellations in one day." Correct; folk-story writers often are inexact. Joshua stopped sun and moon, instead of the earth. Yet classical myths are serviceable. They add color to cold facts, yield the derivation of constellation names, and help us to remember locations and details of the starry heavens. Also, they dovetail neatly into history, philosophy, art, and literature.

On mid-January evenings, three constellations in the west and southwest—faint Pisces, dark Aries, and great Cetus with its widely scattered stars—harmonize with the dim River. Contrasted with it are the dying Swan and the bright Nubian family of the northwest, as well as Orion, Canis Major, and Gemini, which flame in the eastern half of the sky.

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 6:30 p.m. on the 7th and for 5:30 p.m. on the 23rd. The moon's position is marked for each five days by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury is in Capricornus, but is not well placed. It reaches greatest elongation east of the sun on January 8th.

Venus, also in Capricornus, is still too near the sun for easy observation. It is in conjunction with Mercury on January 16th.

Mars is moving eastward in Ophiuchus, visible in the pre-dawn sky.

Jupiter, retrograding in Gemini, shines brilliantly below Castor and Pollux. It is in opposition to the sun on January 11th, when it will be 393,800,000 miles from the earth.

Saturn remains near Aldebaran in Taurus. It is retrograding.

Uranus is in Taurus (see special article on page 22); *Neptune* is in Virgo; *Pluto* is in Cancer.

The earth will be at perihelion on January 2nd at 1:00 a.m., when its distance from the sun will be 91,447,000 miles.

DEEP-SKY WONDERS

FROM the treasures of the January sky, the following are suggested for amateur observation:

Diffuse nebula: N.G.C. 2024, Orion, $5^h\ 37.8^m$, $-1°\ 54'$.

Globular: N.G.C. 1851, Columba, $5^h\ 12.3^m$, $-40°\ 06'$.

Clusters: N.G.C. 1245, Perseus, $3^h\ 7.8^m$, $+46°\ 52'$; N.G.C. 752, Andromeda, $1^h\ 51.8^m$, $+37°\ 11'$; M41, Canis Major, $6^h\ 42.7^m$, $-20°\ 38'$; M44 (Praesepe), Cancer, $8^h\ 34.3^m$, $+20°\ 20'$; M67, Cancer, $8^h\ 45.8^m$, $+12°\ 11'$.

Galaxies: N.G.C. 1232, Eridanus, $3^h\ 7.5^m$, $-20°\ 46'$; N.G.C. 2841, Ursa Major, $9^h\ 18.6^m$, $+51°\ 12'$.

Planetaries: N.G.C. 1535, Eridanus, $4^h\ 12^m$, $-12°\ 53'$; N.G.C. 2022, Orion, $5^h\ 39^m$, $+9°\ 04'$; N.G.C. 7662, Andromeda, $23^h\ 23^m$, $+42°\ 14'$.

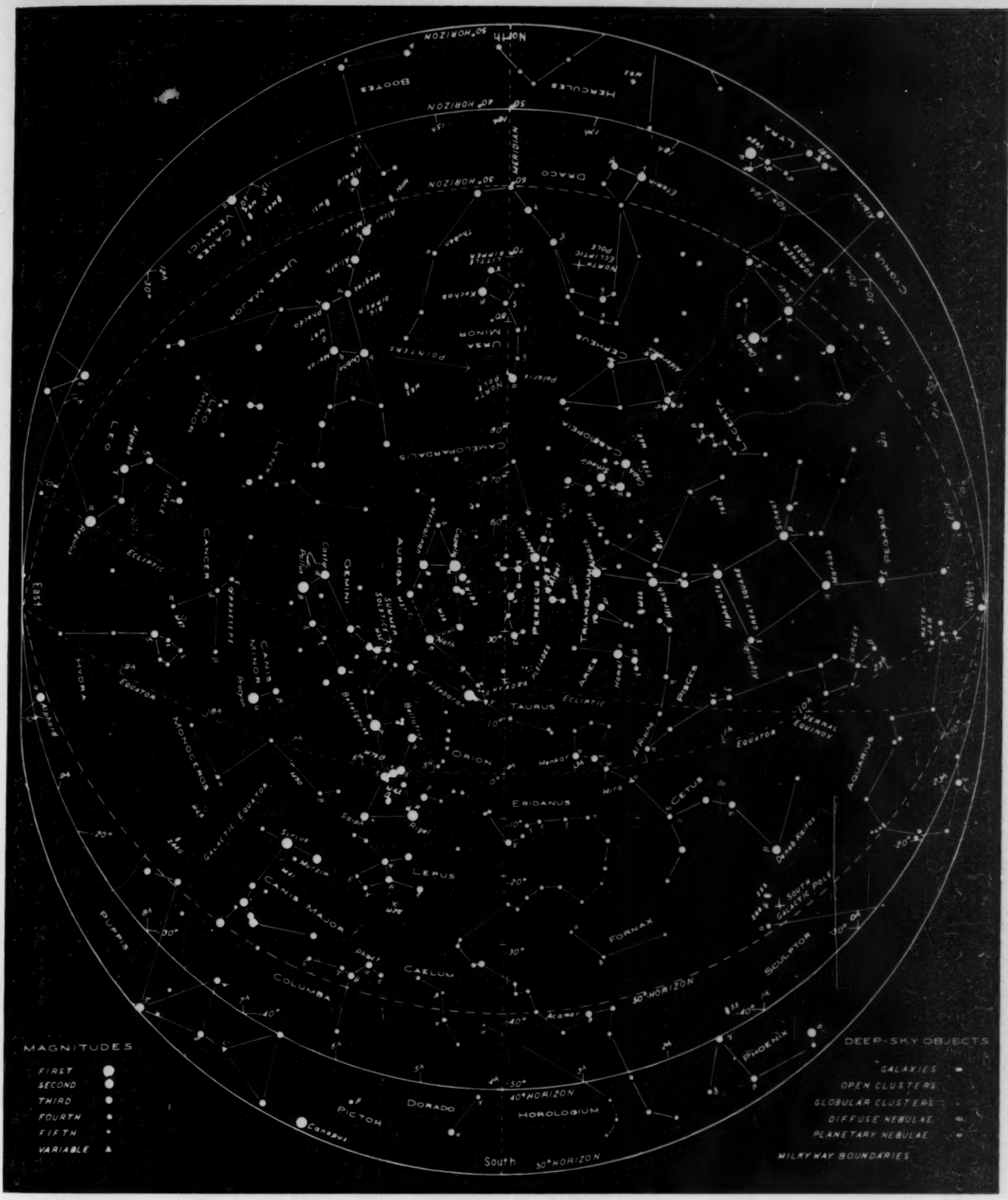
REPTILES OF THE NIGHT

YOU have read that in Mesozoic times reptiles ruled our globe. That was more than 100 million years ago—or before the light that reveals to us the nearer galaxies started on its journey earthward. Our animal ancestors, biologists tell us, once looked somewhat like lizards.

Perhaps in simian days our forebears began to fear snaky things. After they became men, they added reverence and even admiration. "Be ye wise as serpents," say the Gospels. Partly because of these strange emotions, men living in the twilight age of the mind traced out three reptiles in the starry heavens—Draco, the Dragon, guarding the north pole of the ecliptic; Serpens, the big crawler held by Ophiuchus; and Hydra, the Water Monster, which stretches more than one quarter of the way around the celestial globe.

Less than 300 years ago, astronomers added Hydrus, the Water Snake, and Chamaeleon, both near the south pole, and little Lacerta, in the stellar northland.

Hevelius devised Lacerta in 1687. It was almost his masterpiece, though none of the


NORTH
MERIDIAN
HERCULES
BOOTES
DRACO
LYRA
CYGNUS
CEPHEUS
CASSIOPEIA
CAMELOPARDALIS
URSA MAJOR
URSA MINOR
CANES VENATICI
COMA BERENICES
LEO
LEO MINOR
LYNX
CANCER
GEMINI
AURIGA
PERSEUS
TRIANGULUM
ANDROMEDA
PEGASUS
CIRCLET
ARIES
PISCES
TAURUS
ORION
ERIDANUS
CETUS
AQUARIUS
HYDRA
MONOCEROS
CANIS MINOR
CANIS MAJOR
LEPUS
PUPPIS
COLUMBA
CAELUM
FORNAX
SCULPTOR
PHOENIX
DORADO
PICTOR
HOROLOGIUM
Ecliptic
Equator
Galactic Equator
Vernal Equinox
Summer Solstice
North Ecliptic Pole
South Galactic Pole
Pointers
Little Dipper
Big Dipper
Great Square
Alpheratz
Algenib
Mirfak
Algol
Capella
Rigel
Aldebaran
Pleiades
Hyades
Betelgeuse
Procyon
Sirius
Canopus
Achernar
Fomalhaut
Deneb Kaitos
Mira
Menkar
Regulus
Spica
Arcturus
Antares
Vega
Deneb
Altair
Rasalhague
Kochab
Polaris
Dubhe
Merak
Mizar
Alcor
Thuban
Eltanin
Rastaban
Algieba
Denebola
Zosma
Alphard
Castor
Pollux
Alhena
Wezen
Adhara
Miaplacidus
Suhail
Naos
Markab
Schedar
Caph
Alpheratz
Hamal
Sheratan
Mirach
Almach
Diphda
Menkar
Acamar
Achernar
Peacock
Ankaa
Nunki
Kaus Australis
Rukbat
Arkab
Sagittarius
Scorpius
Antares
Rasalhague
Alphecca
Kornephoros
Ras Algethi
Ras Alhague
Sabik
Yed Prior
Yed Posterior
Unukalhai
Zubenelgenubi
Zubeneschamali
Alphekka
Izar
Seginus
Muphrid
Arcturus
Spica
Vindemiatrix
Porrima
Denebola
Algieba
Regulus
Adhara
Sirius
Rigel
Betelgeuse
Aldebaran
Capella
Pollux
Procyon
Alhena
Wezen
Mirzam
Murzim
Canopus
Achernar
Fomalhaut
Deneb Kaitos
Mira
Menkar
Hamal
Sheratan
Mirach
Almach
Diphda
Alpheratz
Algenib
Markab
Schedar
Caph
Navi
Ruchbah
Segin
Gamma Cassiopeiae
Polaris
Kochab
Pherkad
Dubhe
Merak
Phecda
Megrez
Alioth
Mizar
Alcor
Alkaid
Thuban
Eltanin
Rastaban
Etamin
Algieba
Denebola
Zosma
Chertan
Alphard
Regulus
Ras Elased Australis
Ras Elased Borealis
Algol
Capella
Rigel
Aldebaran
Pleiades
Hyades
Betelgeuse
Procyon
Sirius

OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

ALGOL AND OTHER VARIABLES

WHILE compiling these notes, I have made several trips to my observing room to watch a perfect dimout of the variable star Algol. Although I have been studying this phenomenon for many years and have recorded several hundred minima, it never becomes monotonous. The systematic observation of variable stars, a branch of amateur astronomy that is of special value, is ably handled by the A.A.V.S.O., but watching a few of the better-known variables may interest the beginner and enable him to gain some additional pleasure and knowledge with his small telescope.

There are several thousand of these stars known to astronomers, 90 per cent of which are telescopic objects and difficult to locate, but each has been classified according to certain peculiarities associated with the fluctuations of its light intensity. The beginner should confine himself to the observation of a very few in each of the three better-known groups, and there is no easier one to start with than the Beta star in Perseus, commonly known as Algol. Binoculars can be used, but a telescope with low magnification, such as a reflector of the richest-field type, will be found more satisfactory.

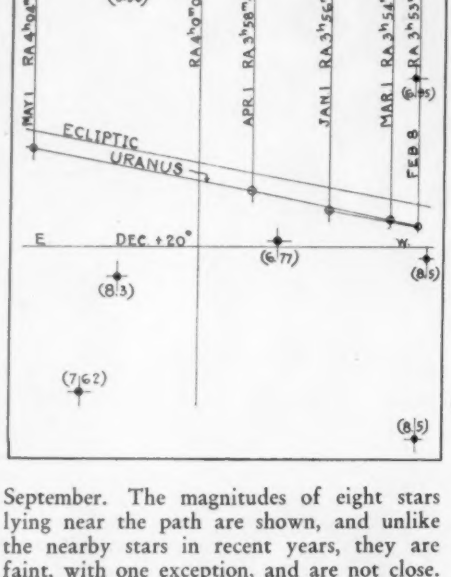
Algol's minima are listed each month on the "Observer's Page." Since it requires about five hours to fade from maximum (magnitude 2.3) to minimum (magnitude 3.5), and about the same period to return to maximum, I would suggest the evenings of January 6th or 23rd, on either of which the five-hour period may be observed before midnight. The Alpha star in Perseus, Marfak, lies 10° slightly east of north of Algol, and its magnitude, 1.90, makes it a little brighter, while Gamma Andromedae, 16° west of Algol, has almost the same magnitude as the variable. South of Algol by about 2° lies ϱ Persei, also a variable, fluctuating between magnitudes 3.3 and 4.1. These stars furnish excellent comparisons for the observation of Algol's minima, one of which occurs at 6:39 p.m. on the 6th. At that time it will be noticed that Algol's dimness approaches that of ϱ and will be almost exactly the same if the latter happens to be at its maximum. The fluctuations of ϱ are very irregular, making it impossible to relate its bright or dim phase to those of Algol.

Frequent observations after 6:39 p.m. and up to almost midnight will be rewarded by seeing the star gradually return to its normal brightness. On January 23rd the order will be reversed, and the observation should begin at about 6:00 p.m., when the star is at its brightest. At 11:34 p.m. it will reach minimum.

It is not the intent of this article to explain the reason for light variations in variable stars. Algol is in the category of eclipsing binaries, and the time interval between minima is 2.87 days. Also in this class, and easily observed, are β Lyrae, with a period of 12.93 days and varying from 3.5 to 4.1; λ Tauri, 3.95 days, with variations from 3.8 to 4.2; and V Puppis, 1.46 days, varying from 4.1 to 4.9. These stars are blue and hot, the color being particularly noticeable in Algol when it is compared with ϱ—cool and red.

THE PATH OF URANUS

THE diagram shows the path of the planet Uranus in Taurus from January 1st to May 1st. Its present retrograde motion will continue until February 8th, to be followed by progressive motion until the middle of September. The magnitudes of eight stars lying near the path are shown, and unlike the nearby stars in recent years, they are faint, with one exception, and are not close. The magnitude of the planet will be about 6.0 throughout the four months. The diagram of stars shown measures about 3° in both latitude and longitude and can easily be contained in the field of 6x to 8x binoculars.



For the beginner, the planet may be difficult to locate. On January 1st it will be less than 1° north of a point 6° west of Saturn. Aldebaran will be almost 4°.5 southeast of Saturn on that date, and this distance and direction should make a good yardstick for locating Uranus.

On March 27th, the planet will be 18′ north of 164 B Tauri, designated on the diagram by its magnitude (6.77). On the 15th of April it will be 1° 24′ south of 37 Tauri, magnitude 4.5, the only bright star in the group.

OCCULTATIONS—JANUARY, 1943

Local station, lat. 40° 48′.6, long. 4h 55.8m west.

Date	*Mag.*	*Name*	*Immersion*	*P.**	*Emersion*	*P.**
Jan. 10	6.4	BD −7° 6036	6:28.4 p.m	100°	7:27.2 p.m.	206°
16	4.0	θ^1 Tauri	5:20.2 p.m.	92°	6:27.6 p.m.	231°
16	3.8	θ^2 Tauri	5:27.6 p.m.	117°	6:16.7 p.m.	206°
16	4.8	264 B Tauri	6:33.7 p.m.	75°	7:54.9 p.m.	247°
16	6.5	275 B Tauri	8:43.0 p.m.	102°	10:03.9 p.m.	227°
16	1.1	Aldebaran	10:25.9 p.m.	93°	11:53.0 p.m.	244°
18	6.2	19 B Geminorum	8:28.1 p.m.	127°	9:26.8 p.m.	217°
25	4.1	σ Leonis	5:01.6 a.m.	59°	5:45.7 a.m.	357°

* P is the position angle of the point of contact on the moon's disk measured eastward from the north point

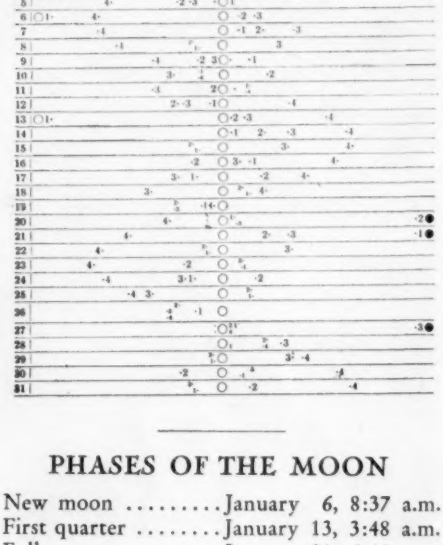
By Jesse A. Fitzpatrick

JUPITER'S SATELLITES

The four principal moons will be west of Jupiter throughout the evenings of January 4th and 25th, and after 0:20 a.m. on the 19th. On January 14th, they will be east of Jupiter after 0:48 a.m. and in numerical order with *I* nearest the primary.

Prior to Jupiter's opposition, the shadow of a satellite is seen to cross the primary before the actual transit of the moon. After opposition, this order is reversed. At the moment of opposition, they transit simultaneously as may be observed on the 11th, when both *II* and its shadow start to cross the disk at 3:28 a.m. Nearly three hours later when they emerge, the satellite will appear one minute before the shadow, demonstrating that the planet has passed the point of opposition.

Jupiter's four bright moons have the positions shown below at 1:45 a.m., E. W. T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the American Ephemeris and Nautical Almanac.



PHASES OF THE MOON

New moon .....January 6, 8:37 a.m.
First quarter .....January 13, 3:48 a.m.
Full moon .....January 21, 6:48 a.m.
Last quarter .....January 29, 4:13 a.m.

The moon will be at perigee on the 6th, when its distance from the earth will be 221,580 miles. This will happen at new moon, so the moon and sun together should cause unusually high tides.

MINIMA OF ALGOL

January 1, 1:00 a.m.; 3, 9:50 p.m.; 6, 6:39 p.m.; 18, 5:56 a.m.; 21, 2:45 a.m.; 23, 11:34 p.m.; 26, 8:24 p.m.

OBSERVING NOVA PUPPIS

(Continued from page 7)

extensive principal shell of gas at a great distance from the star. Among these were the one at 4686 angstroms, due to ionized helium, and a strong band due to neutral helium. The latter falls close to the sodium lines, but the change is evident from a small shift of position of the bright band between the second and third strips in Figure 2. The ionized helium band shows the central minimum of strength very prominently. The emergence of these new emissions is evidence that the effective surface of the radiating cloud close about the star has become much hotter, and its radiation stimulates the emission of these high-excitation lines in the remote principal shell of gas. Besides these newcomers in the bright-band spectrum, the auroral and 6300-6363 lines of oxygen had become much stronger. This can be attributed to the increasingly rarefied condition of the outward-moving principal shell of gas after 10 more days' expansion.

The spectra in Figure 2 give an insight into the meaning of the apparent change of color of the nova, as viewed directly with a telescope. Near maximum the star appeared white, but as it faded it became very red. The spectrum shows that near maximum, November 12th, there was strong continuous spectrum in all colors, but later it became very weak, and the bright red Hα band showed up "like a house afire." Thus the change of color of the star was due simply to the dominance of this one bright band, and not to a concentration of light in the red region of the *continuous* spectrum.

On the morning of December 8th, we obtained two excellent spectra of Nova Puppis. Not much change had occurred in the blue-violet region. In the visual region, however, the auroral line and 6300 and 6363 lines of neutral oxygen had strengthened further. The forbidden lines of ionized nitrogen in the yellow-green region, at 5755 angstroms, had become quite strong since November 30th. This line may be expected to undergo further strengthening. In some novae, it has become the strongest line of the visual region, with the exception of Hα.

Novae in general seem to follow fairly well-defined rules of behavior. One of these is the relation between the velocity of the gases and the rate of fading of the star. If the velocity of expansion is "slow"—a mere 100 or 200 miles per second—the star will decline in brightness quite slowly, and usually irregularly. But if the velocity is high—say, 1,000 miles per second—the light will fade rapidly. Only occasionally does a distinct exception arise. So, when Nova Puppis showed dark lines with a velocity of about 700 miles per second, I expected that it would decline at about the average rate of a magnitude in perhaps 10 days. Very soon it became clear that I was mistaken; the star dropped through fully two magnitudes in four days, as fast a decline as that of any typical nova. Incredulous of such a marked failure of the rules of the game, I then suspected that it might flare up again within a week or two, and so make the *average* rate of fading considerably less. A parallel case from the past was that of Nova Geminorum 1912, which had a second maximum of light 10 days after the principal maximum. But again the prediction failed, so far as any of our observations indicate. The nova continued merrily on its way toward oblivion. At last it became evident that Nova Puppis was repeating the practically unique behavior of Nova Cygni 1920, which was another star with an average speed of expansion, but a very high rate of fading. It is at least comforting to find a parallel case in history, even though it complicates the problem by making an exception appear less exceptional!

A question of considerable interest is: "What will Nova Puppis do next?" I have already pointed out its failures to abide by the rules. Nevertheless, when the spectrum is considered by itself, without relation to the decline of light, the course of events was fairly normal. With that as a basis, as I write we may expect that the month of December will see the following changes: 1. The bright bands of ionized iron will weaken and perhaps disappear. 2. Additional bright bands of helium and of ionized nitrogen will appear in the spectrum. 3. The green nebular lines of doubly ionized oxygen will emerge, at least faintly. Throughout these changes the hydrogen bright bands will remain very conspicuous.

During January, 1943, the nebular lines of doubly ionized oxygen should become rapidly much stronger, and eventually they should outshine even the hydrogen lines. The lines of neutral oxygen may be expected to weaken. These changes have occurred in all novae that have been observed in sufficient detail, and there is no basis for a suspicion that Nova Puppis will depart radically from the normal pattern.

If the light curve follows that of the suspected prototype, Nova Cygni 1920, it should level off between the 7th and 8th magnitudes, and perhaps even brighten a little during February. But prediction of the light curve is much less dependable than that of the spectroscopic behavior, and we may be due for more surprises.

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PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *January*, ABC OF ASTRONOMY.

Designed for all who wish an all around picture of the great universe about us, the Buhl Planetarium's January Sky Show includes everything from meteors to galaxies. Here visitors have a graphic survey of the cosmos telescoped into one short hour through the magic of lenses and mirrors. We find which of the beautiful spectacles of the heavens take place, like the northern lights, in the oceans of air above, and which, like eclipses of sun and moon, occur in the vast oceans of empty space beyond. We get acquainted with the planet Mars, seeing it, spinning in space like a cosmic top, as though we were but a few thousand miles distant. A birdseye view of the solar system shows us where the earth fits into the scheme of things. Then, leaving the little family of the sun, we examine those other suns, the stars, and the fantastic island universes which lie so unbelievably far away. In "ABC of Astronomy" is offered a simple, visual explanation of the celestial phenomena everyone sees in the sky but which still are puzzling and mysterious to many.

★ **THE HAYDEN PLANETARIUM** presents in *January*, STARS OF A WINTER NIGHT.

The story of the stars is an old one but ever new. In "Stars of a Winter Night" Hayden Planetarium audiences will see the ancient constellation figures and hear retold again the stories of these fantastic people and animals in the stars. The modern view of the stars will be presented by beautiful photographs from our leading astronomical observatories.

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Mondays through Saturdays (except Tuesdays).....3 and 8:30 p.m.
Sundays and Holidays.....3, 4, and 8:30 p.m.
(Building closed Tuesdays)

★ STAFF—*Director*, Arthur L. Draper; *Lecturer*, Nicholas E. Wagman; *Manager*, Frank S. McGary; *Public Relations*, John J. Grove; *Chief Instructor of Navigation*, Fitz-Hugh Marshall, Jr.; *Instructor, School of Navigation*, Edwin Ebbighausen.

★ SCHEDULE HAYDEN PLANETARIUM

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Saturdays .....11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays and Holidays.....2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Assistant Curators*, Marian Lockwood, Robert R. Coles (on leave in Army Air Corps); *Scientific Assistant*, Fred Raiser; *Lecturers*, John Ball, Jr., Charles H. Coles, Charles O. Roth, Jr.